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The Status of Land Management Practices on Agricultural Land in Canada

Centre for Land
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terres et les ressources biologiques

Canada

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The images represent the Research Branch's objective: to improve the long-term competitiveness of the Canadian agri-food sector through the development and transfer of new technologies.

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THE STATUS OF LAND MANAGEMENT PRACTICES ON AGRICULTURAL LAND IN CANADA

Compiled from the
1991 Canada Census of Agriculture

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PREFACE

Maintenance of land quality and soil health, and the control and amelioration of land degradation, is strongly influenced by procedures of land management. Farmers and other land managers in Canada are the stewards of the nation's agricultural land resources, and it is their decisions that most directly affect how the land will be managed. The farming community, however, is strongly influenced by various agricultural policies and programs, as well as by controls and opportunities dictated by national and international markets. Farmers' decisions on land management are made within the broader objectives of remaining economically viable and maintaining their quality of life, and they are not independent of the requirements and controls of society at large. Thus, although farmers are the prime instruments for delivery of improved systems of land management, the ultimate responsibility for the quality and health of the nation's lands is shared by all segments of society.

The total area of improved cropland in Canada is about 45.5 million hectares, and there are approximately 248 thousand farmers and other land owners (out of a total of approximately 280 thousand) who reported having cropland. This report outlines how the collective actions of this large number of individual decision-makers affect this large and diverse land area.

The report is designed to establish a baseline for answering questions such as: how effectively are we managing agricultural lands in Canada? Is the quality and health of Canadian soils getting better or worse? Are there regions in Canada in which management techniques are better than in others? If so, what are the reasons? Are there regions where inadequate practices are contributing to major environmental concerns? This report provides guidance to some of these questions, but more importantly, it establishes the first point on the trendline from which such concerns (and many others) can be monitored in the future. Many of these issues can only be resolved by observing performance over time.

Many people and institutions have contributed to this report. Special recognition is accorded to the Prairie Farm Rehabilitation Administration (PFRA), who contributed technical advice in designing the Land Management module for the 1991 Agricultural Census, and contributed financially to analyzing the data. The Agriculture Division of Statistics Canada prepared the data summaries, with the assistance and patient guidance of Dr. E.C. Huffman, CLBRR. State of Environment Reporting, Environment Canada, assisted in publishing and distributing the report. Appreciation for reviewing the manuscript is extended to Dr. C.A. Campbell and to Dr. D.F. Acton. Thanks are also extended to the Cartographic Design and Reproduction Unit of CLBRR, who prepared the manuscript for publication.

This report is a chronicle of how farmers reported on agricultural land management during the 1991 census reporting period; these data have not been independently verified. All interpretations of the data contained in this report are the responsibility of the authors. The report is not to be interpreted in any way as being the official policy of any government agency or department.

INTRODUCTION

Conservation is a big concern for most Canadians today. People expect that Canada's natural resources will continue to exist in a "healthy" state and be productive for generations to come. For this to happen, however, Canada's land must be managed in a *sustainable* way.

Sustainable Land Management

Sustainable land management means managing the land in a way that keeps it productive without depleting resources or harming the environment. This kind of management requires a change in thinking and a change in habits. Land should be thought of as a bank. If we think that the land is an unlimited resource from which we can continuously "withdraw", our account will eventually be used up. If, instead, we are wise stewards and invest back into the land, our account will balance and will continue to give us a good return in the future.

Agriculture and Agri-Food Canada, in cooperation with provincial and private sector partners, is developing principles of sustainable land management. New policies and technologies are being developed to support a land management system built on five pillars:

- Productivity — maintaining or improving agricultural production and services
- Stability — reducing the level of production risk
- Protection — conserving natural resources and preventing degradation of soil and water
- Viability — making good economic sense
- Acceptability — maintaining social acceptance

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One of Canada's most valuable resources is the soil. A healthy soil — one that is able to accept, store, and cycle water, nutrients, and energy over a sustained period — is better able to produce food and fibre for the needs of Canadians and the world's growing population. In this way it helps to keep Canada competitive in world markets. Soil also acts to stabilize natural ecosystems and to improve water quality, making it a major contributor to overall environmental quality.

Although the total area of farmland in Canada has decreased over the past 20 years, there has been a steady increase in the amount of farmland used to grow crops (Table 1). This increasing demand on the soil to be productive poses a risk to soil health. The way soils are managed for agriculture may actually decrease their productivity.

Table 1: The use of farmland in Canada, 1971–1991

Land Use	1971	1976	1981	1986	1991
Total Farmland (million ha)	68.7	68.4	65.9	67.8	67.8
Cropland[1] (million ha)	27.8	28.3	31.0	33.2	33.5
Summerfallow[2] (million ha)	10.8	10.9	9.7	8.5	7.9
Improved Pasture[3] (million ha)	4.1	4.1	4.4	3.6	4.1
Improved Cropland[4] (million ha)	42.7	43.3	45.1	45.3	45.5
Improved Cropland/Total Farmland (%)	62.2	63.3	68.4	66.8	67.1

[1] Cropland is the total area on which field crops, fruits, vegetables, nursery products, and sod are grown

[2] Summerfallow is area that has been left idle (not worked) for at least one year

[3] Improved Pasture is area improved by seeding, draining, irrigating, fertilizing, brush or weed control, not including areas where hay, silage, or seeds are harvested

[4] Improved Cropland is the sum of cropland, summerfallow, and improved pasture

(Source: *Census Overview of Canadian Agriculture, 1971–1991*, Minister of Industry, Science and Technology 1992)

Certain land management practices break down the structure of the soil, speed up the loss of nutrients, increase the risk of erosion, and generally cause deterioration of soil quality. When this happens, the soil is less able to perform its natural functions, and the loss is felt environmentally and economically. Different practices are often needed, not just to halt the destruction of our soils, but to rebuild them.

In recent years agricultural research has developed field practices that promote soil conservation, but how widely are such practices used in Canada? This question has been difficult to answer because no comprehensive inventory of these practices was available. To remedy this, Agriculture and Agri-Food Canada's Centre for Land and Biological Resources Research and the Prairie Farm Rehabilitation Administration (PFRA) worked with the Agricultural Division of Statistics Canada to design a new land management module for the Canada Census of Agriculture. This module was first introduced in the 1991 Census, and results are presented in this report.

The objectives of this report are:

- to record how agricultural land is used and managed in Canada
- to produce a study that will serve as a baseline for all subsequent monitoring of land management practices through the census
- to provide information useful for environmental studies of soil and water quality.

USING THIS REPORT

Along with questions about crops, animals, buildings, equipment, and operating costs, the 1991 Census of Agriculture[1] questionnaire (Step 12) asked farmers to report on the use of the following land management practices:

- application of fertilizers, herbicides, insecticides, and manure[2]
- irrigation[2]
- erosion control practices, such as the use of forages in crop rotations, winter cover crops, grassed waterways, strip-cropping, contour cultivation, and windbreaks[3]
- weed control on summerfallow land, using chemicals, tillage, or a combination of the two[3]
- tillage methods used to prepare land for seeding, such as conventional tillage, conservation tillage, and no tillage (no-till)[3]
- salinity control[3].

This report summarizes the information on land management contained in the 1991 Census of Agriculture. It is the first authoritative reporting of land management practices in Canada; it is a "snap shot" of how land was being managed on the nation's farms during the Census reporting period. However, in using the report one must keep in mind that the findings are summarized from the opinions of the approximately 280,000 farmers who responded to the questions contained in the Census, and that there are always some possibilities for mis-interpretation.

Some comparisons of estimates contained in this report were made against other sources, but the results were not always clear. This does not necessarily signify error in this report or any other, but rather that land management activities used by Canadian farmers often have more than one objective. Thus, activities reported under the umbrella of land management in the Census may be reported under some other objective in another report — and both may be correct.

[1] conducted on June 4, 1991, in conjunction with the Census of Population
[2] reported for 1990
[3] reported for 1991

An example of this is the use of forage rotations, reported in the Census as being for the purpose of soil conservation. In reality, forages are used in Canada for many reasons other than soil conservation. However, in the Census the farmers reported all forages on their farms as being for soil conservation, and questioning this interpretation is not within the scope of this report. Generally speaking, it is more useful to know to what extent and where forages are grown in Canada, than whether or not the specific intent of the farmer was to conserve soil. Forages in rotation provide excellent cover against erosion and a good buffer against other sources of degradation, regardless of their intended use. Similarly, the adoption of conservation tillage is currently being driven more by attempts to reduce operating costs than by soil conservation, but this is not an important difference for this report, providing that the latter objective is being achieved. Perhaps these distinctions could be better explored in subsequent censuses, if this was deemed to be important.

The possible mis-interpretation of a question in the census form is a perpetual source of concern for all who work with and report on census data. Examples of such possible mis-interpretations that may affect this report are the use of conservation tillage, strip cropping, contour cultivation and wind breaks. It is impossible to be certain, in the absence of corroborative information, whether or not these are reported correctly. In these cases, one has to accept the unbiased procedures employed by Statistics Canada, whereby each question is thoroughly field tested and validated in a series of regional workshops before it is included in the Census.

This report cites land management information from the 1991 Census, and it gives a series of cross-tabulation tables showing the frequency of each land management practice compared to other variables contained in the Census. The purpose of the cross-tabulation tables is to illustrate how the various land management practices fit within the broader objectives of on-farm management. They should not be interpreted as cause-effect relationships. For example, soil conservation practices are more common on farms with computers than on

farms without computers. This does not mean that computers are currently being used as decision-making tools in soil conservation; it may, however, mean that farmers with computers are better educated and more innovative, and, therefore, they are more likely to employ soil conservation technologies.

For some questions, farmers simply reported whether or not a practice was used. For other questions, they reported the area of land on which a certain practice was used. When reading this report, it is important to keep this distinction in mind. The following example explains how the census information was interpreted:

Example:

(A) 166 thousand out of 248 thousand farmers with cropland[4] report using fertilizer.
166 ÷ 248 x 100 = 67 percent of farmers with cropland use fertilizer.

(B) 21,543 thousand hectares out of 41,429 thousand hectares of cultivated land[5] receive fertilizer.
21,543 ÷ 41,429 x 100 = 52 percent of cultivated land receives fertilizer.

The first calculation gives the proportion of farms that use a particular land management practice. This indicates the extent of adoption (or non-adoption) of the practice by the farming community. The second calculation gives the proportion of land receiving the treatment, which is the area of cropland being affected by the practice.

Statistics Canada groups agricultural census data by geographical area. Data are released at five levels of geography: Canada, Province, Census Agricultural Region (CAR), Census Division (CD), and Census Consolidated Subdivision (CCS). In this report, the overview of land management practices in Canada presents data at the national and provincial levels (data from the Yukon and Northern Territories were not included). The summaries of regional and provincial land management practices present data at both the provincial and CCS levels and highlight trends at the divisional (CD) and regional (CAR) levels.

[4] cropland is land on which crops are grown
[5] cultivated land is the sum of cropland plus summerfallow

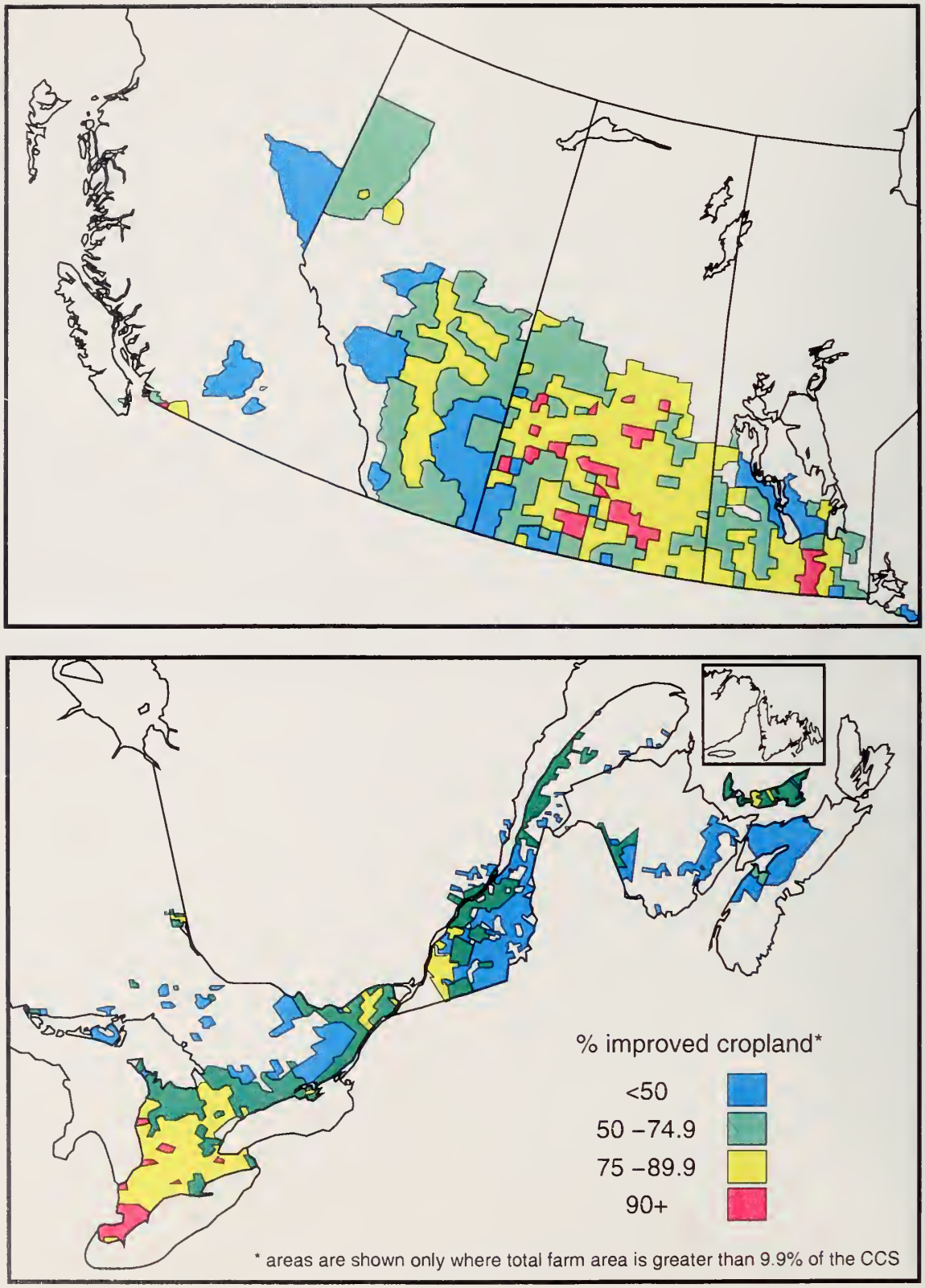

Figure 1. Area of improved cropland as a percent of total farmland area.

OVERVIEW OF LAND MANAGEMENT PRACTICES IN CANADA

There are over 280 thousand farms in Canada, representing a land area of about 70 million hectares. This *total farm area* includes all lands owned, rented, or sharecropped that are used for crops, grazing and pasture, summerfallow, buildings and barnyards, bush, sloughs, and marshes.

About 67 percent of farmland in Canada is *improved cropland* (a combination of cropland, summerfallow, and improved pasture; Figure 1). The share of total farmland made up by improved cropland has increased by 8 percent since 1971 but has stabilized over the past 10 years (Table 1). On the other hand, cropland has increased by 20 percent, while summerfallow has decreased by 27 percent over this period (this expansion of cropland is not expected to change by very much in the future). The Prairies and the central provinces have the largest proportion of their total farm area converted to improved cropland (56 to 75 percent), but by far the largest area of improved cropland is in Saskatchewan (20.2 million hectares), a province whose vast natural grasslands have been largely converted to agricultural land over the past century. In contrast, British Columbia and the Atlantic provinces, with the exception of Prince Edward Island, have a much lower proportion of improved cropland (23 to 40 percent). Newfoundland, whose rocky landscape, cool climates and poorer soils, has the smallest area and proportion of improved cropland (11 thousand hectares).

Table 2 shows how the provinces compare in total number of farms, total farm area, and average farm size. Ontario (68.6 thousand farms), Saskatchewan (60.8 thousand farms), and Alberta (57.2 thousand farms) have the most farms of all the provinces. Saskatchewan and Alberta have the country's largest farms (440 and 360 hectares, respectively), while Ontario and Newfoundland have the smallest (80 and 65 hectares, respectively). This variation in farm size reflects the type of farming that takes place in the different regions of the country. For example, cereal production in the Prairies is more extensive in area than cash crop production in Ontario.

Agricultural Benchmark Sites

Farming practices vary across Canada, ranging from traditional methods of cultivation and cropping to conservation methods with reduced tillage and erosion controls. To assess how these different farming methods affect the quality of soil, long-term soil and farm management data are needed.

Twenty-two *benchmark sites* were selected and sampled across Canada between 1989 and 1992. These sites, each about five hectares, represent common farming practices for typical Canadian soils, landscapes, and climate. Detailed climate information and maps of contour and soil types are available for each site.

Soil samples are collected annually from each site for laboratory analysis and archiving (storage for future reference). All important soil properties (physical, chemical, and mineralogical) are analyzed, some every year and others every five years. In addition, farm management and yield data are collected each year. Changes in soil properties over time will be used to determine the effects of farming practices on soil under certain conditions.

C. Wang, Agriculture and Agri-Food Canada, Ottawa, Canada

Table 2: Provincial farm statistics, 1991 Census

Province	No. of farms (thousand)	Total Farm Area (million ha)	Average Farm Size (ha)
British Columbia	19.2	2.4	125
Alberta	57.2	20.8	365
Saskatchewan	60.8	26.9	440
Manitoba	25.7	7.7	300
Ontario	68.6	5.5	80
Quebec	38.1	3.4	90
New Brunswick	3.3	0.4	115
Nova Scotia	4.0	0.4	100
Prince Edward Island	2.4	0.3	110
Newfoundland	0.7	<0.1	65
Canada	280	67.8	242

APPLICATIONS TO THE SOIL

The use of chemicals (fertilizers, herbicides, insecticides) and manure in Canada is shown in Figure 2. Commercial fertilizers are applied to over half of the cultivated land in Canada. Although over 40 percent of farms report applying manure to the land, the area involved is relatively small (about five percent, or only about one tenth of that receiving commercial fertilizers). This is not surprising since manure is not available in all areas, whereas commercial fertilizers are more readily available and more easily handled. Herbicides are applied to over half of the cultivated land in Canada, while insecticides, which are more specific and local in their use, are applied to only about seven percent of the cultivated land.

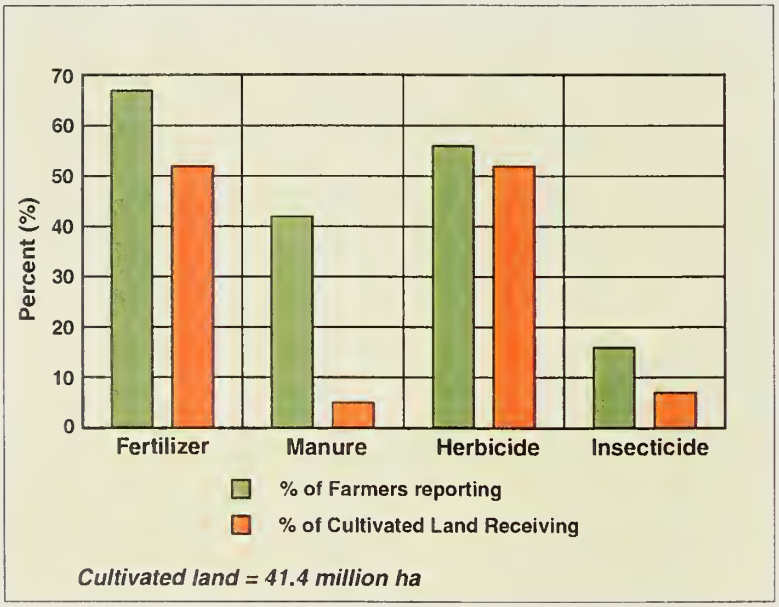

Figure 2. Chemical and manure use in Canada, 1991 Census.

Nutrient Additions — Fertilizers and Manure

Fertilizers

Fertilizers are applied to a soil to improve the soil's capacity to supply plant nutrients in quantity and at rates required by a crop. In agricultural soils, nutrients have to be applied to replace those taken up by the crop and removed during harvesting, as well as those lost through erosion, leaching, and vaporized into the atmosphere. When used in a responsible manner, the addition of nutrients in the form of fertilizers can increase crop production in years of favourable growing conditions, improve a farm's chances of economic survival by reducing losses in years of unfavourable growing conditions, and maintain or improve the quality of soils.

Fertilizers offer an advantage over manure because they can be applied when the crop needs nutrients the most, and the amount of nutrients applied can be precisely controlled (manure releases nutrients continuously, even when plant needs are low). Their greatest positive effect is when the receiving soil is low in plant nutrients (low fertility) but has adequate moisture. Fertile soils that have a good natural store of plant nutrients can produce high crop yields on their own, and fertilization will generally be minimal.

Applying the correct amount of fertilizer is important. By applying too little fertilizer, a soil may be "mined" of its plant nutrients, and crop yields may become progressively lower over the years. This is a sign of *soil degradation*. Soil testing can determine the nutrient needs of a soil and the right amount of fertilizer to apply.

Applying more fertilizer than a soil needs (which may result from following general fertilization guidelines for a crop and soil) will not result in higher yields. Over-fertilization wastes fertilizer resources and money, and the surplus plant nutrients may overload the soil and cause environmental harm by contaminating surface and groundwater and the atmosphere.

In general, a larger share of farms in the Atlantic provinces report using fertilizer than in other parts of Canada (Table 3), reflecting that soils in these areas are less fertile than in other regions. Manitoba, Nova Scotia, and Newfoundland use fertilizers on the largest proportion of cultivated land. On an area basis,

Table 3: The use of fertilizers and manure in Canada, 1991 Census

Province	Farms with cropland (thousands)	Cultivated land[1] (thousand hectares)	Farms with cropland reporting use of (%)		Cultivated land[1] receiving (%)	
			Fertilizers	Manure	Fertilizers	Manure
British Columbia	14.3	614	61	45	54	13
Alberta	50.7	11,063	65	29	57	3
Saskatchewan	58.7	19,172	61	18	40	1
Manitoba	23.6	5,058	72	30	73	3
Ontario	61.4	3,475	72	61	65	19
Quebec	31.2	1,653	67	71	60	33
New Brunswick	2.6	124	73	67	63	24
Nova Scotia	3.2	107	76	70	77	37
Prince Edward Island	2.1	155	80	74	66	17
Newfoundland	0.5	6	79	63	85	51
Canada	**248.1**	**41,429**	**67**	**42**	**52**	**5**

[1] cropland + summerfallow

Table 4: The use of fertilizers and manure in Canada, 1991 Census (percent of farms reporting)

Selected Variables		Fertilizers	Manure
Improved Cropland (ha)	1–14	41	35
	15–60	58	47
	61–100	69	50
	101–150	69	40
	151+	74	30
Farm Type	Dairy	79	87
	Cattle	50	52
	Wheat	63	8
	Oilseeds	80	4
	Silage Corn	89	89
	Grain Corn and Sunflowers	90	19
	Field Beans/Peas	85	10
	Hay and Fodder	37	13
	Potato	83	33
	Other Field Crops	85	23
Days Off-farm Work	None	63	41
	1–59	62	33
	60–190	56	30
	191+	50	31
Farm Organization	Family Holding	59	37
	Family Corporation	68	45
	Non-family Corporation	48	29
Sales/ha[1] ($)	1–299	57	23
	300–625	69	41
	626–1500	71	56
	1501–2700	76	70
	2701+	63	54
Computer	Farm with	68	41
	Farm without	58	37

[1] hectare of improved cropland

Saskatchewan reported using fertilizer on the lowest percent of cultivated land. This is probably because of the high proportion of total production which comes from fallow land where additional fertilizers are often not applied, the high risk of drought and the consequent risks of not obtaining positive returns, and the high cost of fertilizers compared to the current market value of wheat. Farmers tend not to invest in fertilizers (or other amendments) unless they are quite sure they will recover the cost. The comparatively higher share of cultivated land receiving fertilizers in Manitoba reflects the more reliable weather and superior soil moisture conditions in this province (mainly in the more fertile Black soil zone), and the greater variety of crops that are grown.

Fertilizer use in Canada (Table 4) is highest on farms:

- with greater improved cropland area
- that grow corn
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family unit
- with sales of $1501 to $2700 per hectare
- with a computer.

Manure

Additions of manure[6] to the soil, like commercial fertilizer, build up the soil's store of plant nutrients, but also improve its structure. Although a large share of Canada's soil nutrient needs could be supplied by manure, limited supply and problems with distribution and lack of consistency of quality mitigate against its widespread use, except in certain regions of eastern Canada. Also, storage of manure is a problem in terms of potential environmental pollution and loss of quality over time. Manure can vary widely in its nutrient and organic matter content, so it is sometimes difficult to determine how much manure should be applied. Adding manure to soil can also introduce unwanted items, like weed seeds, bacteria, and toxic chemicals.

The big difference between the share of farmers that use manure and the share of cultivated land that receives manure in each province (Table 3) is a sign that manure is a limited resource that is applied to the land when it is available. The prairie provinces report the lowest use of manure in Canada, while British Columbia and Central and Atlantic Canada report higher manure use.

Manure use in Canada (Table 4) is highest on farms:

- with 15 to 150 hectares of improved cropland (although all farms will tend to use manure whenever it is available)
- with dairy cattle
- that grow silage corn
- where the farmer does not work off the farm
- organized as a family unit
- with sales of $1501 to $2700 per hectare.

Manure is spread on cultivated land mainly as a way of disposing of farm animal waste. Land application of manure is high in

Making the Most of Manure

Manure is rich in plant nutrients and organic matter. Canada's large population of farm animals (about 114 million, mostly cattle, swine, and poultry) produced an estimated 129 million cubic metres of manure in 1991. If this manure was spread evenly over the cultivated lands in Canada, it would supply over half the nitrogen and phosphorus and all the potassium needed for crop production.

Manure should be regarded as a valuable soil amendment, not just a waste product requiring disposal. Current research is looking at nutrient availability from manure, better methods of storage and application, and agronomic, economic, and environmental aspects of using manure.

	A	B	C
Nitrogen	675	1,200	480
Phosphorus	190	270	230
Potassium	450	320	190
Total	1,315	1,790	900

A - Estimated production of plant nutrients in manure in Canada, 1990 (thousand tonnes)

B - Estimated fertilizer nutrient consumption in Canada, 1990 (thousand tonnes)

C - Estimated value of plant nutrients in animal manure in equivalent fertilizer prices ($ million)

after Patni, 1991

E.G. Gregorich, Agriculture and Agri-Food Canada, Ottawa, Canada

[6] This is barnyard manure only; it does not include sewage sludges, for which data on application rates are not available

regions where farm animal production is high and the manure can be collected and distributed easily. Manure use is lower in areas where production of manure is low or distribution is difficult. For example, in the Prairies, cattle are concentrated only in certain areas, and fields are large and require large amounts of manure for complete coverage. Although Alberta's large cattle population produces over 25 percent of all the animal manure in Canada[7], only a small proportion are confined dairy cows, where manure collection and land application are practical. Beef farms are not suited for land application of manure, except from cow-calf operations and feedlots.

Manure in British Columbia and central and eastern Canada comes mostly from dairy and poultry farms, which are numerous and scattered throughout crop production regions. This makes it easier to get the manure to the fields where it is needed. Many dairy farms grow silage corn as cattle feed, and the manure from the cattle is applied to the corn fields, creating an on-farm nutrient cycling system. This relationship between manure use and dairy and silage production is borne out in the census data. For example, 90 percent of Canadian farms that produce silage corn are located in Ontario and Quebec[8]. These provinces together produce about 35 percent of Canada's animal manure, almost half of it from dairy cows[9]. Ontario and Quebec report relatively high use of manure on cultivated land (Table 3), and this use is highest on dairy farms and farms that grow silage corn (Table 4). Potatoes, another crop associated with high manure use, is grown by about a quarter of Prince Edward Island's farms on 18 percent of its improved cropland.

Herbicides and Insecticides for Controlling Weeds and Pests

Weeds and insect pests can cause huge economic losses in crop production. Controls involve combinations of cultivation and crop rotations, and usually include the judicious use of pesticides, including herbicides and insecticides.

Herbicides

Weeds reduce yields (in some cases by over 50 percent) by competing with the crop for light, moisture, and nutrients. They also decrease the value of the harvested crop. If weeds are allowed to grow unchecked, weed infestation results in progressively higher production costs and lower yields for many years.

Herbicides are used on about half of the cultivated land in the prairie provinces, Ontario, and Prince Edward Island (Table 5). Newfoundland (9 percent), Nova Scotia, and British Columbia (both at 21 percent) reported the lowest use of herbicides. Herbicide use is highest on farms (Table 6):

- with larger improved cropland area
- that grow corn or sunflowers, field beans or peas, other field crops, or wheat
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family unit
- with a computer.

Herbicide use does not appear to be closely linked to per-hectare sales (Table 6), which probably means that a certain level of chemical weed control is used in most farm operations.

What Happens to the Chemicals?

Current farming practices in Canada include the application of pesticides and the incorporation of industrial by-products and waste materials, like sewage sludge, into soil. These products contain industrial organic compounds (IOC), such as polychlorinated biphenyls (PCBs) and benzo(a)pyrene, that have been implicated in environmental degradation. There is a concern that these compounds may accumulate in soils and cause problems for crop production and human and animal health.

Assessment of the impact of land management practices includes developing procedures to determine the fate of IOCs in soils. A recent study by Agriculture and Agri-Food Canada in conjunction with the Wastewater Technology Centre examined 30 Canadian agricultural soils, including six intensively cropped southern Ontario soils that had received repeated recent pesticide applications. Only trivial amounts of IOCs were found in the soils. It was concluded that Canadian agricultural and waste management practices do not represent a significant IOC hazard to crop production or the food-chain.

M.D. Webber, Wastewater Technology Centre, Burlington ON

[7] from Patni, N.K. 1991. *Overview of Land Application of Animal Manure in Canada.* Proceedings of the National Workshop on Land Application of Animal Manure, Canadian Agricultural Research Council.

[8] *Census Overview of Canadian Agriculture: 1971–1991.* 1992. Minister of Industry, Science and Technology

[9] Patni, *op. cit.*

Farmers know that weeds will be a problem every year and weed control, including the use of herbicides, is built into the regular farming routine, regardless of farm earnings. Continual herbicide use can lead to problems with weeds developing tolerance to some herbicides.

Insecticides

Insect infestations may alter crop growth and cause enormous damage and destruction of the crop. Responsible use of insecticides is usually necessary to control insect pests, but relying only on chemical controls can create problems because such practices can cause resistance of the pest to the chemical, destruction of a pest's natural enemies, increase secondary pests to problem levels, possible environmental contamination, potential health hazards, and negative public attitude.

Successful insect control programs begin with prevention — maintaining healthy soils and the pests' natural enemies, and using crop rotations to break the cycle of pest recurrence. The decision to use a pesticide depends on the cost of the chemical and application compared to the value of the crop loss and damage if a pesticide is not used.

Insecticides are less widely used in Canada than herbicides. Only in the Maritime provinces, Ontario, and Manitoba are insecticides used on more than 10 percent of cultivated land (Table 5). This is because they are not applied routinely, often only when monitoring shows that a pest has reached a certain population level. Use of insecticide is highest on farms (Table 6):

- with one to 14 hectares of improved cropland and those with more than 150 hectares of improved cropland
- that grow potatoes, or, less importantly, grain corn or sunflowers, or other field crops
- where the farmer works off the farm one to 59 days in a year
- organized as a family corporation
- with higher per-hectare sales
- with a computer (almost twice as high as on farms without).

The link between the use of insecticides and per-hectare sales indicates that insecticides are used more frequently to protect valuable crops (crops that produce high dollar value per hectare), like potatoes and fruit. In contrast, insecticide use is low on land cropped to wheat and oilseeds. In the Prairies, insecticides are generally used only when seeding, tillage and rotation practices have not successfully con-

Table 5: The use of herbicides, insecticides, and irrigation in Canada, 1991 Census

Province	Farms with cropland (thousands)	Cultivated Land[1] (thousand) hectares)	Farms with cropland reporting use of (%)			Cultivated land[1] receiving (%)		
			H	I	IR	H	I	IR
British Columbia	14.3	614	29	22	44	21	6	15
Alberta	50.7	11,063	53	8	8	51	5	4
Saskatchewan	58.6	19,172	71	15	2	52	5	<1
Manitoba	23.6	5,058	63	21	1	65	12	<1
Ontario	61.4	3,475	55	23	5	52	13	2
Quebec	31.2	1,653	46	13	5	34	6	1
New Brunswick	2.6	124	33	24	5	32	20	1
Nova Scotia	3.2	107	33	20	6	21	13	2
Prince Edward Island	2.1	155	57	31	1	48	23	<1
Newfoundland	0.5	6	24	28	7	9	9	2
Canada	248.1	41,429	56	16	7	52	7	2

[1] Cultivated land is a combination of cropland and summerfallow

H = Herbicides, I = Insecticides, IR = Irrigation

Table 6: The use of herbicides, insecticides, and irrigation in Canada, 1991 Census (percent of farms reporting)

Selected Variables		Herbicides	Insecticides	Irrigation
Improved Cropland (ha)	1–14	23	20	18
	15–60	39	12	6
	61–100	56	13	4
	101–150	61	13	4
	151+	75	18	4
Farm Type	Cattle	32	5	5
	Wheat	75	16	2
	Oilseeds	69	14	1
	Grain Corn and Sunflowers	80	29	2
	Silage Corn	78	20	4
	Field Beans/Peas	78	18	1
	Hay and Fodder	20	5	5
	Potato	70	70	20
	Other Field Crops	76	24	7
	Other	38	38	26
Days Off-farm Work	None	53	15	6
	1–59	56	17	7
	60–190	46	14	6
	191+	38	12	6
Farm Organization	Family Holding	49	14	6
	Family Corporation	57	24	13
	Non-family Corporation	38	17	11
Sales/ha[1] ($)	1–299	54	11	2
	300–625	53	14	5
	626–1500	53	16	7
	1501–2700	60	22	9
	2701+	48	32	23
Computer	Farm with	61	23	11
	Farm without	48	13	6

[1] hectare of improved cropland

trolled an insect problem and when the cost of applying the insecticide is offset by the potential economic loss due to insect damage of the crop. Insecticide treatment of the soil is often too expensive for grain crops and is reserved for crops that give higher returns per hectare, like potatoes.

Irrigation

Irrigation is used to ensure that a crop receives adequate water at the right time. Proper management of irrigation takes into account the water requirements of the crop, the water-holding capacity of the soil, the amount of water lost through evaporation and transpiration, and the weather.

Only British Columbia and Alberta report the use of irrigation at a significant level (Table 5). Although 44 percent of British Columbia farms report using irrigation on 15 percent of the cultivated land, this comprises only about 92 thousand hectares. Eight percent of Alberta farms report using irrigation on four percent of cultivated land, but this represents an area of 443 thousand hectares. About five percent of farmers in the Central and Atlantic regions report using irrigation on one to two percent of their cultivated land. The exception is Prince Edward Island, which, along with Saskatchewan and Manitoba, reports very low use of irrigation, both by the share of farmers (one to two percent) and by the share of land (less than

Blowing in the Wind

Topsoil is the foundation for all agriculture in Canada. A healthy topsoil, full of plant nutrients and organic material, can produce abundant crops. But each year in Canada, mostly in the Prairies, millions of tonnes of topsoil are swept off the land by wind. In 1986, a year of exceptionally high erosion, almost 15 percent of cultivated lands were affected by moderate and severe wind erosion. At a soil-loss rate of 10 tonnes per hectare, this means that at least 63 million tonnes of prairie topsoil were lost, representing an environmental and economic loss of about $30 million.

Predicting a soil's susceptibility to wind erosion is difficult. Such a prediction must consider the forces of the wind, as well as changing soil surface conditions, and vegetation and residue cover. A new prediction technology currently under development in the United States (USDAIARS), known as the "Wind Erosion Research Model (WERM)", is being studied by Agriculture and Agri-Food Canada. This model predicts soil, moisture, and residue characteristics, and then uses long-term weather records to estimate the probability and severity of an erosion event. The effects of management practices, such as tillage, on the "erodability" of a soil can also be predicted.

Such a model could be used to help farmers decide what crops and management practices to use at a certain time in order to reduce the effects of wind erosion.

Glenn Padbury, Agriculture Canada, Saskatoon SK

half of one percent). Irrigation is more likely to be used on farms (Table 6):

- with one to 14 hectares of improved cropland
- that grow potatoes or crops classified as "Other"
- organized as a corporation (family or non-family)
- with higher per-hectare sales
- with a computer (almost twice as likely as on farms without).

CONTROL OF SOIL EROSION

Erosion is a process that removes and redistributes soil materials from the land, resulting in soil degradation. The main agents of soil erosion are wind, water, and tillage. Maintaining a continuous vegetative cover on the soil is usually the best way to control erosion.

Wind erosion, or "soil drifting" is caused by the action of wind on exposed soil, especially smooth, unprotected surfaces. Wind picks up finer soil particles and deposits them downwind. Improper tillage practices, low soil moisture, poor soil cover or any combinations thereof can increase the risk of wind erosion.

Water erosion occurs when rain, spring runoff, or floodwater carry soil particles away. This can occur through sheet erosion, where soil materials are removed relatively uniformly, or rill erosion where flowing water creates small channels in the soil, called rills, and larger channels, called gullies. The extent of water erosion depends on the amount of soil cover, soil texture, the length and grade of the field slope, the amount and timing of heavy rainfall, and the tillage and cropping practices used.

Tillage erosion happens when the action of tilling drags soil downhill. The extent of tillage erosion depends on the shape and gradient of the slope, the type of equipment, depth of tillage, the speed at which tillage equipment is used, and the number of tillage operations.

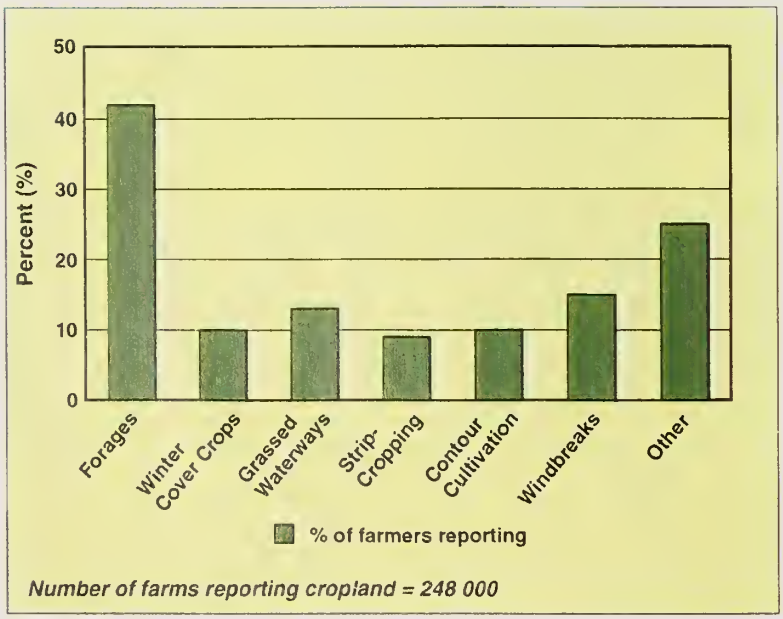

Figure 3. Erosion control practices on cropland in Canada, 1991 Census.

Water Erosion

Water erosion is a process where soil is detached, transported, and deposited by raindrop impact or overland flow. Although it is a natural process, it is often aggravated by agricultural management practices, resulting in decreased crop productivity. In 1986 an estimated 13 percent of Canada's cultivated lands lost more than 10 tonnes of soil per hectare because of water erosion. This loss was worth more than $400 million. Water erosion can also cause high loading of sediments and agricultural chemicals into streams and other water bodies.

Agriculture and Agri-Food Canada is currently monitoring erosion of soils under a wide range of management practices. Results of these studies are used to validate and improve water erosion prediction models, such as the Water Erosion Prediction Program (WEPP). These models help identify areas at high risk of water erosion and show the benefits of conservation management, including cross-slope and contour cultivation, crop rotations, and conservation tillage. This information can help farmers make good management choices that will improve their soil quality and crop productivity and reduce the environmental damage of water erosion.

Elizabeth Pringle, Agriculture and Agri-Food Canada, Guelph ON

All three erosion processes may happen in a single field. Various land management techniques, designed to create barriers to the displacement of soil, are used to protect soil from erosion losses (Figure 3). Some erosion control practices are more common in certain areas in Canada (Table 7).

Growing forages in rotations is the most common erosion control practice in Canada (Figure 4); 42 percent of farms report this practice (Table 7), but they tend to be concentrated in the more humid regions of the country. Prince Edward Island (72 percent) leads the country in this practice. Ontario (60 percent) and Quebec (52 percent) also report substantial use of forages in rotations, mainly because they are leading growers of silage corn, the crop most associated with this practice (both forages and silage corn are grown as livestock feed) (Table 8). In contrast, Saskatchewan and Manitoba report relatively low use of this practice. In general, the semi-arid regions of the Prairies have little opportunity to use forages for erosion control due to inadequate soil moisture during the growing season; in contrast, the important practice of "stubble mulch cropping" is commonly employed in these areas for erosion control.

The second most common erosion control practice is the use of windbreaks or shelterbelts, which are lines of trees or bushes planted at the borders of or within fields, normally at right angles to the prevailing winds (maintaining natural vegetation along fencelines has the same effect). This technique is most commonly used in the Prairies (29 to 37 percent of farms),

Table 7: Erosion control practices in Canada, 1991 Census (percent of farms with cropland reporting)

Province	Farms with cropland (thousands)	F	WCC	GW	SC	CC	WB
British Columbia	14.3	23	11	10	2	5	13
Alberta	50.7	43	7	17	10	11	29
Saskatchewan	58.6	22	6	12	21	18	35
Manitoba	23.6	35	7	13	5	13	37
Ontario	61.4	60	20	15	4	7	21
Quebec	31.2	52	4	4	3	4	8
New Brunswick	2.6	44	10	9	5	8	8
Nova Scotia	3.2	34	12	8	3	8	7
Prince Edward Island	2.1	72	9	11	4	10	16
Newfoundland	0.5	37	7	4	1	7	12
Canada	248.1	42	10	13	9	10	15

F = Forages in rotations, WCC = Winter Cover Crops, GW = Grassed Waterways, SC = Strip-cropping, CC = Contour Cultivation, WB = Windbreaks

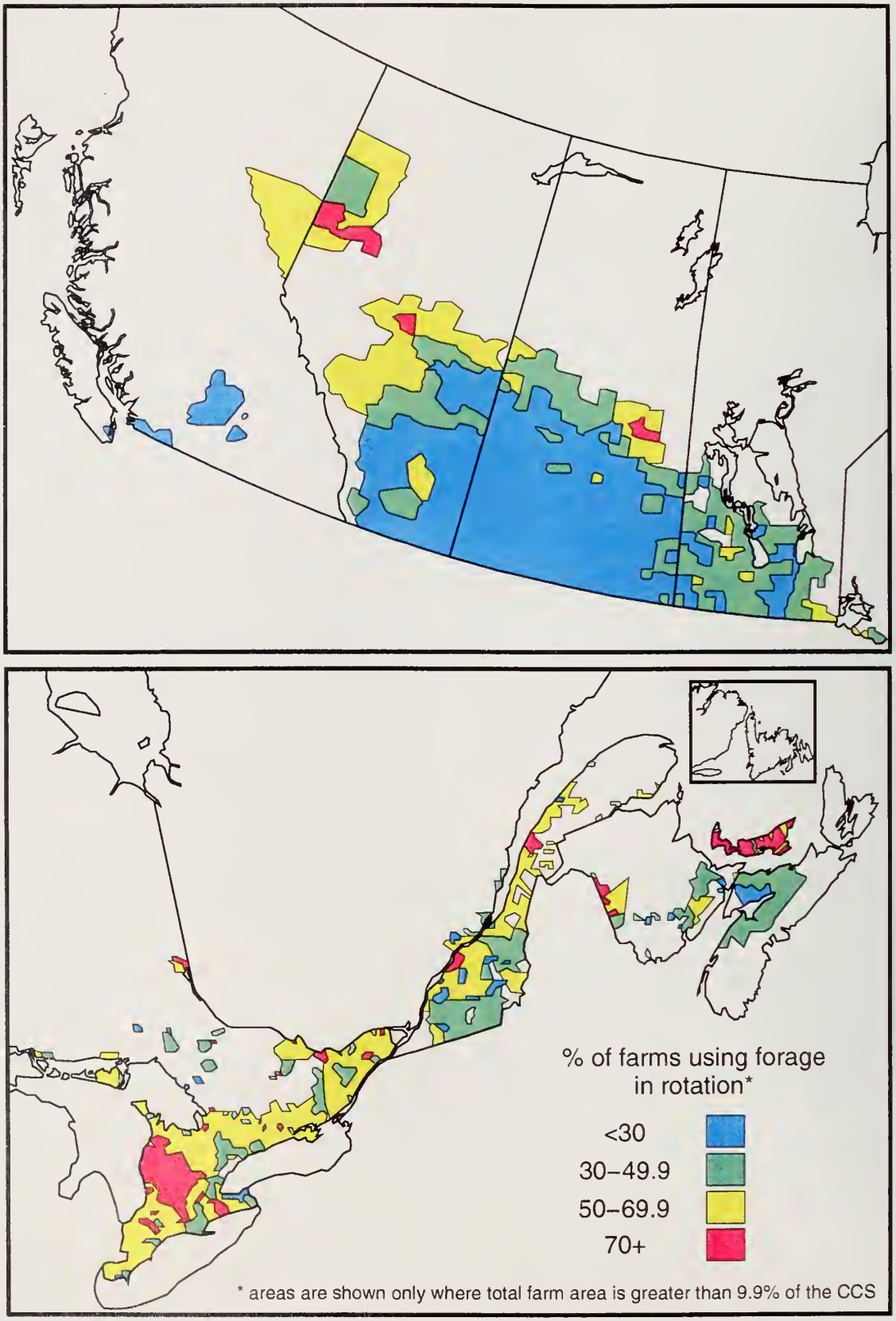

Figure 4. Percent of farms reporting use of forage in rotation.

Canadian Farms Use Windbreaks

- 13 percent (36 thousand) of Canadian farms report having windbreaks to conserve soil
- The total length of windbreaks in Canada is 84 thousand kilometres. If planted in a row, these trees would circle the equator twice.
- The prairie provinces have the most windbreaks in Canada. In Saskatchewan, windbreaks are used on 35 percent of farms reporting cropland and total 34 thousand kilometres. Thirty seven percent of Manitoba farms and 29 percent of Alberta farms with cropland use windbreaks for soil conservation.

Source: The Daily, Statistics Canada, 4 June 1992

where the flat terrain, minimal natural brush protection, large fields, and frequency of high winds make cultivated land especially vulnerable to wind erosion. Ontario farms also report substantial use of windbreaks (21 percent of farms).

Other erosion control methods involve maintaining a cover on the soil, particularly at times of the year when soil is most vulnerable to erosion. Winter cover crops, such as fall rye and winter wheat, can be planted after fall harvest so that soil is not left exposed over the normally barren and highly erosive fall and spring months. Ontario farms report using winter cover crops at double the figure for all of Canada (20 percent versus 10 percent). Grassed waterways, which are grassy strips in run-off depressions that provide a route for excess water, are generally used more in western Canada and Ontario than in the east.

Tillage and planting practices that reduce erosion include contour cultivation and strip-cropping. Contour cultivation is cultivation that follows the contours of a field, producing furrows that run perpendicular or at angles to the slope-line of a field. This creates an irregular surface that breaks up the downslope movement of water and thus reduces water erosion of the soil. This cultivation technique is practised mainly in the Prairies (11 to 18 percent of farms) and Prince Edward Island (10 percent of farms). Strip-cropping, a technique that involves alternating strips (50 to 200 metres wide) of crop and summerfallow or of two crops across a field, is less commonly used in Canada.

In general, erosion control practices are more common on farms (Table 8):

- where the farmer works off the farm fewer than 60 days in a year
- organized as a family unit
- with a computer (although the difference, compared to farms without a computer, is small for the use of forages in rotation, strip-cropping, and contour cultivation).

Grassed waterways, strip-cropping, contour cultivation, and windbreaks are all used most on farms with more than 150 hectares of improved cropland. Forages in rotations and winter cover crops are used most on farms with 15 to 150 hectares of improved cropland.

Weed Control Methods on Summerfallow

Summerfallow is a practice by which producers grow no crop on the land (the land is "rested") for a single growing season. The amount of Canadian farmland devoted to summerfallow has decreased steadily over the past 15 years (Table 1). Summerfallow is used mainly in the semi-arid portions of the Prairies and, to some extent, in British Columbia (Table 9). All other provinces reported that less than two percent of farmland is summerfallow.

The primary purpose of summerfallow in the Prairies is to conserve soil moisture, and reduce the risk of drought. Weeds growing on summerfallow, however, will deplete soil moisture, and therefore, they must be controlled. Tillage is the most commonly used method of weed control on summerfallow in Canada (Figure 5), but control by chemicals or a combi-

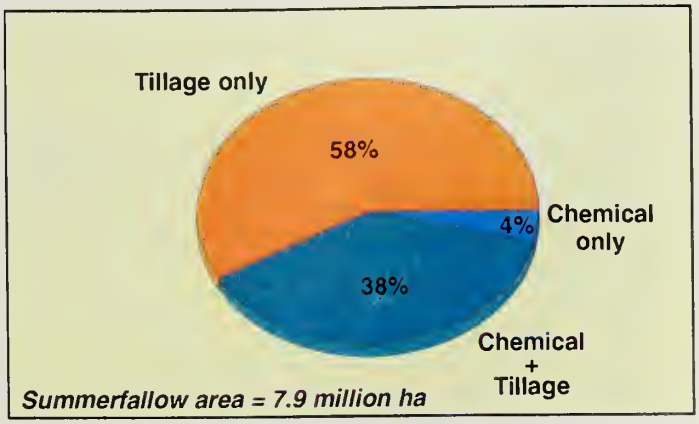

Figure 5. Weed control practices on summerfallow in Canada, 1991 Census.

Table 8: Erosion control practices in Canada, 1991 Census (percent of farms reporting)

Selected Variables		F	WCC	GW	SC	CC	WB
Improved Cropland (ha)	1–14	19	7	7	2	4	10
	15–60	47	10	9	3	6	11
	61–100	54	11	11	6	9	11
	101–150	48	10	13	8	11	13
	151+	35	9	17	17	15	19
Farm Type	Wheat	15	6	11	24	18	17
	Oilseeds	31	4	13	5	16	16
	Grain Corn and Sunflowers	44	17	12	3	8	16
	Silage Corn	80	17	15	5	7	10
	Field Beans/Peas	58	23	11	2	7	18
	Hay and Fodder	45	6	8	2	4	12
	Potato	57	24	13	10	14	15
Days Off-farm Work	None	38	9	12	9	9	13
	1–59	37	10	14	10	10	17
	60–189	36	8	11	7	10	14
	190+	34	8	10	6	8	13
Farm Organization	Family Holding	37	8	11	8	9	13
	Family Corporation	39	14	14	8	8	16
	Non-family Corporation	26	8	7	6	6	10
Sales/ha[1] ($)	1–299	32	7	12	13	13	15
	300–625	42	9	14	6	10	15
	626–1500	53	12	11	4	7	12
	1501–2700	60	14	12	4	6	10
	2701+	34	14	10	4	5	12
Computer	Farm with	40	13	17	10	10	20
	Farm without	37	8	11	8	9	12

[1] hectare of improved cropland

F = Forages in rotations, WCC = Winter Cover Crops, GW = Grassed Waterways, SC = Strip-cropping, CC = Contour Cultivation, WB = Windbreaks

Table 9: Weed control practices on summerfallow in Canada and selected provinces, 1991 Census

Province	Farms with summerfallow (thousands)	Summerfallow (thousand ha)	Summerfallow/ Improved Cropland (%)	Chemical Only		Tillage Only		Tillage and Chemical	
				A	B	A	B	A	B
British Columbia	1.6	57	7	7	3	80	66	22	31
Alberta	19.0	1,771	14	6	5	67	58	38	37
Saskatchewan	45.6	5,713	28	7	4	66	57	40	39
Manitoba	7.5	297	6	4	3	78	73	25	24
Canada	80.8	7,921	17	7	4	68	58	36	38

A = % of farms that reported having summerfallow reporting, B = % of summerfallow receiving this treatment

Table 10: Weed control practices on summerfallow in Canada, 1991 Census (percent of farms reporting)

Selected Variables		Chemical Only	Tillage Only	Tillage + Chemical
Summerfallow (ha)	1	7	79	18
	2–20	5	76	24
	21–50	5	70	32
	51–70	5	65	38
	71+	9	65	45
Farm Type	Wheat	6	49	31
	Other Small Grains	2	35	14
	Oilseeds	3	31	20
	Fields Beans/Peas	1	3	2
	Potato	2	9	4
	Other Field Crops	3	30	20
Days Off-farm Work	None	2	21	11
	1–59	3	23	14
	60–189	2	20	11
	190+	1	15	7
Farm Organization	Family Holding	2	20	11
	Family Corporation	2	13	10
	Non-family Corporation	2	11	7
Sales/ha[1] ($)	1–299	4	36	20
	300–625	1	16	9
	626–1500	1	7	3
	1501–2700	1	4	2
	2701+	1	5	2

[1] hectare of improved cropland

N.B. where values for the three weed control practices add up to more than 100 percent, this indicates overlap between practices

nation of chemicals and tillage is becoming more common. Of the prairie provinces, Manitoba reports the highest use of tillage only (73.3 percent of summerfallow area) and the lowest use of chemicals only (2.7 percent of summerfallow area) to control weeds (Table 9).

A comparison of weed control practices on summerfallow (Table 10) shows:

- the use of tillage only to control weeds decreases as the area of summerfallow increases, but the use of chemicals or a combination of tillage and chemicals is highest on farms with more than 71 hectares of summerfallow
- the use of tillage only is most common on family holdings, but farm organization does not appear to be too important.

Tillage Methods Used to Prepare Land for Seeding

For over a century Canadian farmers tilled the land in a way that incorporated most of the crop residue (plant material remaining after harvest) into the soil. Tillage studies have shown that this method, known as *conventional tillage*, can contribute to soil degradation and erosion losses by removing the cover provided by crop residues and disturbing soil structure.

Conservation tillage (also called mulch tillage, minimum tillage, and reduced tillage) is now becoming more popular (although the practice of mulch tillage has been used by prairie farmers for over 25 years). Methods of conservation tillage leave most of the crop residue on the surface of the soil to provide protection against erosion, reduce soil crusting, and increase the organic matter content of surface soils. Conservation tillage is also a good choice

when a farmer wants to reduce the frequency and cost of tillage (depending on the costs of herbicides).

No-till is any system where the soil is not disturbed between harvesting one crop and planting the next. This method includes direct seeding into stubble or sod, as well as "ridge-tillage". Ridge tillage is a highly specialized method in which crops are planted on constructed ridges that are maintained over many years.

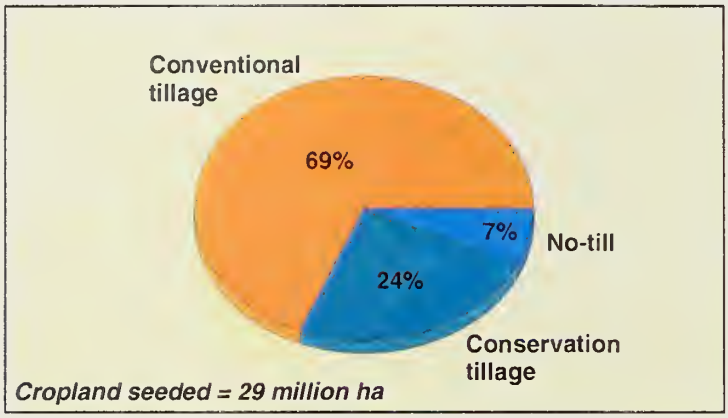

Figure 6. Tillage methods in Canada, 1991 Census.

Conventional tillage is still the most popular method of tillage in Canada, although conservation tillage is making rapid gains. The data (Figure 6) show that alternative tillage methods are being used on one quarter of the land seeded in 1991 (over 7 million hectares). The Prairies lead the country in practising conservation and no-till (Figure 7, Table 11) because of the great need in this region to reduce the impact of wind erosion. Comparing tillage methods by crop (Table 12) confirms that conservation tillage techniques are associated with wheat and other grains. These crops are suited to this type of tillage because the amount of residue left on the surface does not interfere with subsequent seeding. Ontario, which reports using conservation tillage on 18 percent of cropland, is a leading grower of grain corn, another crop associated with this method (Table 12). Conservation and no-till methods are used at relatively low levels in the Atlantic provinces. Prince Edward Island reports the highest use of conventional tillage in Canada.

Table 11: Tillage practices used to prepare land for seeding in Canada, 1991 Census

Province	Farmers with cropland (thousands)	Seeded Land (thousand hectares)	Conventional Tillage		Conservation Tillage		No-till	
			A	B	A	B	A	B
British Columbia	14.3	241	87	83	11	12	9	5
Alberta	50.7	7,966	83	73	21	24	5	3
Saskatchewan	58.6	13,035	74	64	28	26	14	10
Manitoba	23.6	4,419	77	66	29	29	9	5
Ontario	61.4	2,508	89	78	19	18	8	4
Quebec	31.2	852	94	85	13	12	5	3
New Brunswick	2.6	62	93	85	12	13	5	2
Nova Scotia	3.2	32	91	88	11	8	7	4
Prince Edward Island	2.1	112	94	91	10	8	5	1
Newfoundland	0.5	2	89	84	10	8	9	8
Canada	248.1	29,029	83	69	22	24	8	7

A = Farms with land prepared for seeding reporting (%), B = Land prepared for seeding (%)

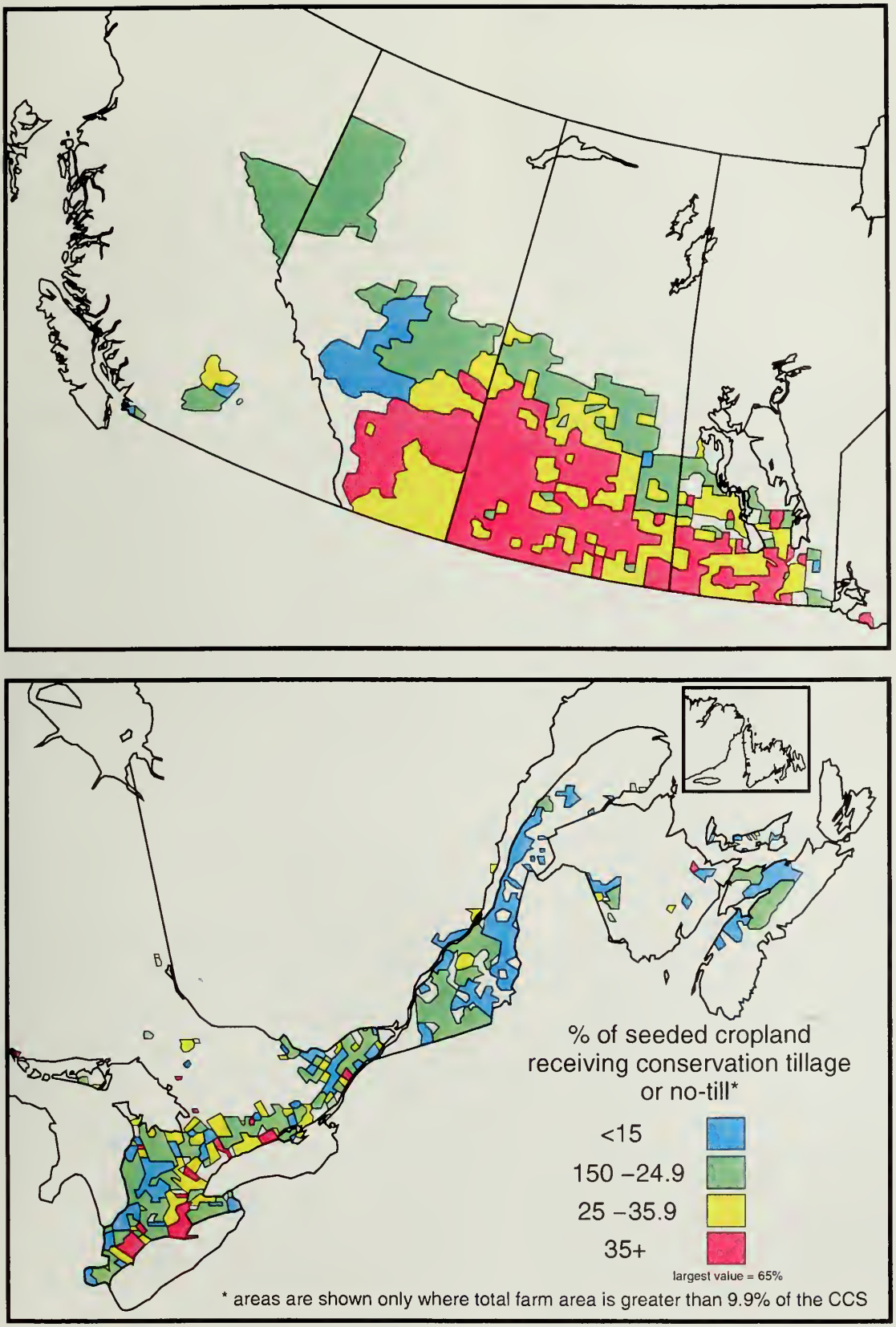

Figure 7. Percent of seeded cropland receiving conservation tillage and no-till.

The use of conventional tillage compared to the use of conservation tillage and no-till (Table 12) shows that:

- conservation tillage and no-till are used most on farms with more than 150 hectares of cropland, whereas the use of conventional tillage is highest on farms with 61 to 150 hectares of cropland
- the relatively high use of conventional tillage on dairy farms is related to the need to dispose of manure by tilling it into the soil
- conservation tillage and no-till are used most by family corporations, whereas conventional tillage is used most by family units
- the use of conservation tillage and no-till is greatest on farms with sales of $1 to $299 per hectare, whereas the use of conventional tillage is greatest on farms with sales of $1501 to $2700 per hectare
- farms with a computer are more likely to use conservation tillage and no-till but the presence of a computer has no effect on the use of conventional tillage.

Table 12: Tillage practices used to prepare land for seeding in Canada, 1991 Census (percent of farms reporting)

Selected Variables		Conventional Tillage	Conservation Tillage	No-till
Improved Cropland (ha)	1–14	43	6	4
	15–60	71	12	5
	61–100	81	18	6
	101–150	80	23	7
	151+	76	31	12
Farm Type	Dairy	85	13	5
	Cattle	58	11	4
	Wheat	72	29	14
	Other Small Grains	81	24	7
	Oilseecds	83	22	5
	Grain Corn and Sunflowers	84	29	8
	Silage Corn	94	19	7
	Field Beans/Peas	88	20	8
	Hay and Fodder	42	6	4
	Potato	90	22	5
Days Off-farm Work	None	66	18	7
	1–59	64	19	9
	60–189	60	15	6
	190+	53	11	5
Farm Organization	Family Holding	63	16	6
	Family Corporation	63	21	8
	Non-family Corporation	49	13	5
Sales/ha[1]	1–299	67	20	8
	300–625	68	18	6
	625–1500	72	16	5
	1501–2700	75	14	5
	2701+	56	11	4
Computer	Farm with	62	23	10
	Farm without	63	15	6

[1] hectare of improved cropland

N.B. values for these tillage practices which exceed 100 percent indicate that several practices are being used on the farm

A New Technology

Soil structure, or "tilth" is a key element of soil quality. Soil structure has an effect on:

- the ability of water and air to move from the soil surface to plant roots
- drainage of excess water from the soil
- erosion of topsoil
- leaching of fertilizers and pesticides into tile drainage water and groundwater

Studying soil structure and its effects on soil quality has been difficult because of soil structure's changeable nature and the lack of good measurement techniques. Development of a new technology, called the *tension infiltrometer technique*, offers a way to define some of the main characteristics of soil structure.

This technique can potentially provide direct measurements of the effect of soil structure on the rate of percolation of water, fertilizers, and pesticides into and through the soil profile. It can also be used to monitor changes in soil structure resulting from changes in land management, such as the introduction of no-till or different crop rotations.

The tension infiltrometer technique is field-based, rapid, and causes only minimal disturbance of the soil. Current research focuses on testing and refining this technique as a means of measuring the aspects of soil structure that relate to soil quality.

W.D. Reynolds, Agriculture and Agri-Food Canada, Ottawa, Canada

Simulating changes in soil organic matter

Soil organic matter is a valuable resource that helps maintain the fertility and productivity of a soil. It can be degraded very quickly by changes in the soil environment or it can be replenished by adding organic materials, like plant residues and manure. In a soil where the amount of organic matter remains steady, the inputs of organic materials equal the output that is lost through decomposition.

Being able to predict how much organic matter will accumulate or decline in a soil helps in managing this resource. This is difficult, because many factors are involved in determining the decomposition of organic matter. Computer models that can simulate changes in soil organic matter can be used to solve this problem.

The CENTURY model is currently being studied by Agriculture and Agri-Food Canada soil scientists. This model uses information and data on the climate (such as moisture and temperature), residue type, erosion, and soil properties (such as texture and pH) to estimate the amount of organic matter in soil. The effects of management practices, such as tillage, crop rotations, and fertilization on the amount of organic matter in soil can also be predicted. Such a model could be used to help scientists and farmers decide which management practices to use on different soils to produce crops over the long term.

E.G. Gregorich, Agriculture and Agri-Food Canada, Ottawa, Canada

Soil Structure

Soil particles are held together in units called aggregates. The size of these aggregates and how they fit together determine a soil's structure. Soil structure affects:

- water storage in the soil (water availability to crops)
- water movement through the soil (infiltration, drainage, and leaching)
- aeration for roots and soil microbes
- the soil's resistance to erosion by wind and water
- the soil's resistance to compaction and crusting

Natural soil structure develops slowly, responding to environmental processes, such as wetting-drying and freezing-thawing, and to inputs of organic matter. Land management practices, including tillage methods, may alter these processes and negatively affect soil structure.

G.C. Topp and K. Wires, Agriculture and Agri-Food Canada, Ottawa, Canada

Computers on the Farm

Canadian farmers are starting to reap the benefits of computer technology. About 11 percent of Canada's farms have a computer. Farmers that use a computer are more likely to:

- use commercial fertilizers, herbicides, and insecticides
- irrigate their cropland
- use erosion controls
- practise conservation tillage

Farmers that use computers tend to be better educated and more willing to experiment with new technologies and farming methods. Computers can make farm operations better by improving record-keeping, speeding calculations, and summarizing information. With more precise information, farmers can make better decisions about farm management and improve farm efficiency.

Soil Organic Matter

Soil organic matter (SOM) is an important component of soils. It is made up of living microbes and invertebrates, as well as dead plant materials. It includes roots and above-ground plant residues, and humified material in various stages of decomposition.

SOM is labile (it can decline rapidly if the soil environment changes) and renewable (it can be replenished by inputs of organic material to the soil). Adequate levels of SOM can be maintained with proper fertilization, crop rotations, and tillage practices.

The functions of SOM include:

- providing plant nutrients
- maintaining soil tilth (condition)
- aiding infiltration of air and water
- promoting water retention
- reducing erosion
- buffering the effect of pesticides

Measuring SOM is one step in assessing overall soil quality. This can be done by measuring various key attributes of soil organic quality, including soil organic carbon and nitrogen, the light fraction, mineralizable carbon and nitrogen, microbial biomass, carbohydrates, and soil enzymes.

E.G. Gregorich, Agriculture and Agri-Food Canada,
Ottawa, Canada

Farm Organization

Canadian farms are categorized in the census as family holdings, family corporations, or non-family corporations. Results of the 1991 Agriculture Census indicate that family farms (holdings and corporations) are more likely to use:

- soil amendments (fertilizers and manure)
- pesticides (herbicides and insecticides)
- erosion control practices
- chemicals only to control summerfallow weeds
- conservation tillage

Why do family farms invest more into the land than non-family holdings? Why are they more likely to use conservation methods?

Family farms make decisions using a team-work approach instead of an administrative hierarchy. Problems and solutions are shared and family members are accountable to each other. There is greater incentive and commitment to keep the land as healthy as possible, both to protect current business interests and to ensure farm productivity for future family generations. Farms owned and operated as family units also benefit from greater loyalty to the business, financial accountability, and reliability and availability of co-operative labour within the family.

REGIONAL AND PROVINCIAL SUMMARIES OF LAND MANAGEMENT PRACTICES

BRITISH COLUMBIA

Province	No. of farms (thousand)	Total Farm Area (million ha)	Average Farm Size (ha)	Improved Cropland Area (million ha)	Percent Improved Cropland	Number of CCSs	No. of CCSs reporting agricultural activity
British Columbia	19.2	2.4	125	0.86	36	82	62

British Columbia comprises 82 Consolidated Census Subdivisions (CCSs), 62 of which reported agricultural activities in 1991. Although the average farm size is about 125 hectares, about 80 percent of the farms are 40 hectares or less. Improved cropland makes up about 36 percent of farmland area; 22 CCSs report that improved cropland makes up more than 50 percent of total farm area (Figure 1). The Mainland Region reports the highest proportion of cropland conversion (Abbotsford, 91 percent; Delta, 86 percent; Burnaby, 85 percent).

Fertilizers

Commercial fertilizers are used on more than 50 percent of cropland in 48 CCSs. Of these, nine report using fertilizer on more than 90 percent of cropland (located in the Columbia-Shuswap, Fraser-Cheam, Dewdney-Alouette, Capital Regional, Nanaimo Regional, Kitimat-Stikine Regional, and Fraser-Fort George Regional Districts). Fertilizers are more commonly used on farms (Table 13):

- with larger improved cropland area
- that grow field crops, wheat, oilseeds (less than three percent of all British Columbia farms)
- organized as a family corporation
- with higher per-hectare sales
- with a computer.

Manure

All CCSs report the use of manure; seven CCSs, mostly in the lower Mainland and Island Regions, use manure on more than 75 percent of cropland. The area of cropland receiving manure is greater or equal to that receiving fertilizer in ten CCSs, all located in the southern part of the province.

The level of manure use, unlike that of fertilizer, does not change very much according to cropland area (Table 13). This means that a farmer with manure to dispose of will apply it to the land regardless of the size of the farm. Farms with the smallest improved cropland area (1 hectare) use manure at the same level (35 percent) as those with the largest improved cropland area (51+ hectares).

Manure use is higher on farms (Table 13):

- with dairy cattle (where there is the greatest need for disposal)
- with higher per-hectare sales (but there is less than a three-fold difference between farms with no sales and farms with the highest sales, compared to fertilizer use which shows an almost eight-fold difference between the two. This supports the fact that manure use is as much a waste disposal system as an investment into the land; even a farm with no income from the land may be obliged to dispose of animal waste)
- that grow potatoes (less than one percent of British Columbia farms) or crops classed as "Other"
- organized as a family corporation
- with a computer.

Herbicides

Herbicide use in British Columbia on cultivated land (Table 5), is less than half the Canadian average. Only two CCSs (Delta and Burnaby) use herbicides on more than 50 percent of cropland.

Table 13: The use of fertilizers, manure, herbicides, insecticides, and irrigation in British Columbia, 1991 Census (percent of farms reporting)

Selected Variables		Fertilizers	Manure	Herbicides	Insecticides	Irrigation
Improved Cropland (ha)	1	38	34	18	23	42
	2–5	49	33	27	30	45
	6–5	53	39	27	24	40
	16–50	55	44	21	9	31
	51+	61	33	27	6	24
Farm Type	Dairy	69	80	37	6	31
	Cattle	46	39	9	2	25
	Wheat	72	5	56	4	2
	Oilseeds	72	0	48	5	1
	Hay and Fodder	38	14	10	3	21
	Potato	62	32	50	49	54
	Other Field Crops	75	8	54	10	8
	Other	60	24	44	51	60
Farm Organization	Family Holding	44	33	20	16	32
	Family Corporation	58	43	36	24	40
	Non-family Corporation	48	27	23	21	34
Sales/ha[1] ($)	0	8	17	3	3	9
	1–299	41	24	13	3	17
	300–625	48	37	14	6	29
	626–1500	49	39	15	11	38
	1501–2700	50	41	23	21	43
	2701+	62	42	42	39	53
Computer	Farm with	54	43	33	22	41
	Farm without	44	32	19	16	32

[1] hectare of improved cropland

Use of herbicides is not linked to area of improved cropland. Herbicides are more commonly used on farms (Table 13):

- that grow wheat, oilseeds, potatoes, or other field crops (about three percent of all British Columbia farms)
- organized as a family corporation
- with higher per-hectare sales (over three times more common on farms with per-hectare sales over $2700 compared to farms with sales under $300 per hectare)
- with a computer.

Insecticides

Insecticides are not widely used in British Columbia (Table 5). They are more commonly used on farms (Table 13):

- with less than 16 hectares of improved cropland
- that grow potatoes or crops categorized as "Other"
- organized as a family corporation
- with higher per-hectare sales
- with a computer.

Irrigation

British Columbia has the greatest share of cropland (15 percent) under irrigation of all the provinces (Table 5). Sixteen CCSs report that more than 50 percent of cropland is irrigated. Of these, five (three in the Okanagan and one in each of the Cariboo and Squamish-Lillooet Subdivisions) use irrigation on more than 80 percent of cropland.

Irrigation is more common on farms (Table 13):

- with less than 16 hectares of improved cropland
- that grow potatoes or crops categorized as "Other"
- organized as a family corporation
- with higher per-hectare sales
- with a computer.

Erosion Control Practices

British Columbia farms report the use of all erosion controls (Table 7), but only forages in rotations (Figure 4), winter cover crops, and grassed waterways are used on a significant share of farmland (Table 14). Growing forages in rotations is the most common erosion control practice. More than 40 percent of farmers use this method in five CCSs, located in the Peace River District and the south central part of the province (Figure 4). All CCSs report growing winter cover crops, but there are only three CCSs where more than 30 percent of farms use this practice (Delta, Powell River Subdivision A, Cowichan Valley Subdivision D).

The use of forages in rotations is highest on farms (Table 14):

- with larger improved cropland area
- that grow wheat, oilseeds, potatoes, or other field crops
- organized as a family unit
- with lower per-hectare sales
- with a computer.

The use of forages in rotations on dairy and cattle farms shows that although this method has benefits for erosion control, its primary purpose is to provide feed for livestock. Although forages are used in rotations on many

Table 14: Erosion control practices in British Columbia, 1991 Census (percent of farms reporting)

Selected Variables		Forages	Winter Cover Crops	Grassed Waterways
Improved Cropland (ha)	1	8	9	5
	2–5	8	8	7
	6–15	14	10	7
	16–50	26	10	7
	51+	45	10	15
Farm Type	Dairy	24	16	6
	Cattle	25	6	9
	Wheat	59	7	17
	Oilseeds	43	6	21
	Hay and Fodder	28	7	7
	Potato	41	27	3
	Other Field Crops	57	10	23
Farm Organization	Family Holding	17	8	8
	Family Corporation	18	12	6
	Non-family Corporation	14	8	6
Sales/ha[1] ($)	1–299	32	7	11
	300–625	24	8	10
	626–1500	19	7	6
	1501–2700	15	10	7
	2701+	11	13	7
Computer	Farm with	14	14	9
	Farm without	7	7	7

[1] hectare of improved cropland

N.B. the effect of working off the farm was studied, but this was not an important factor

grain, oilseed, and potato farms in British Columbia, these farms make up only two percent of all farms in the province.

Winter cover crops are more commonly grown on farms (Table 14):

- that grow potatoes or have dairy cattle
- organized as a family corporation
- with a computer.

Use of this erosion control practice is not linked to improved cropland area and increases only slightly with higher per- hectare sales.

Grassed waterways are used more on farms (Table 14):

- with larger improved cropland area (the increase is not gradual; instead, there is a sharp increase in the use of this practice when the farm has more than 50 hectares of improved cropland)
- with lower per-hectare sales (although the difference between sales categories is small).

Tillage Methods Used to Prepare Land for Seeding

Conventional tillage is used to prepare 87 percent of land for seeding in British Columbia (Table 11); only one CCS reports using this tillage method on less than 50 percent of land prepared for seeding. Central Kootenay Subdivision B reports using conventional tillage to prepare 19 percent of land for seeding, and conservation tillage and no-till to prepare 73 percent. Thompson-Nicola Subdivision B reports using conservation tillage on 21 percent of land prepared for seeding, and four CCSs (Richmond, East Kootenay Subdivision C, Dewdney-Alouette Subdivision A, Capital Subdivision A) report using no-till on 20 percent of land prepared for seeding.

A comparison of tillage methods (Table 15) shows that conservation tillage and no-till are used most on farms that grow wheat, oilseeds, and potatoes (comprising only a small share of British Columbia farms), as well as other field crops. Conservation tillage methods appear to be associated with lower per-hectare sales.

Table 15: Tillage methods used to prepare land for seeding in British Columbia, 1991 Census (percent of farms reporting)

Selected Variables		Conventional Tillage	Conservation Tillage	No-till
Cropland (ha)	1	28	5	3
	2–6	22	4	3
	7–15	32	3	4
	16–40	47	5	5
	41+	69	8	4
Farm Type	Dairy	56	6	11
	Wheat	92	18	4
	Oilseeds	88	14	4
	Potato	89	16	4
	Other Field Crops	94	16	6
Farm Organization	Family Holding	29	4	3
	Family Corporation	39	5	4
	Non-family Corporation	31	3	3
Sales/ha[1] ($)	1–299	44	6	4
	300–625	36	5	3
	626–1500	31	4	4
	1501–2700	27	3	4
	2701+	31	4	4
Computer	Farm with	37	5	5
	Farm without	29	4	3

[1] hectare of improved cropland
N.B. the effect of working off the farm was studied, but this was not an important factor

THE PRAIRIES (Alberta, Saskatchewan, and Manitoba)

Province	No. of Farms (thousands)	Total Farm Area (million ha)	Average Farm Size (ha)	Improved Cropland Area (million ha)	Improved Cropland (%)	No. of CCSs	No. of CCSs reporting agricultural activity
Alberta	57.2	20.8	365	12.8	62	74	65
Saskatchewan	60.8	26.9	440	20.2	75	302	297
Manitoba	25.7	7.7	300	5.4	70	138	117

Saskatchewan has the largest farm area and average farm size of all the provinces. Seventy-five percent of the total farm area is improved cropland, the highest cropland conversion in Canada. Improved cropland makes up more than 50 percent of farmland in 285 CCSs and more than 90 percent in 33 CCSs (Figure 1).

In Alberta, improved cropland makes up more than 50 percent of farmland in 57 CCSs, and over 80 percent in eight of these, located in the central part of the agricultural zone.

In Manitoba, improved cropland makes up more than 50 percent of farmland in 103 CCSs and over 75 percent of much of the southern part of the province.

Fertilizers

Manitoba reports the highest use of fertilizers in the Prairies (73 percent of cultivated land, Table 3), followed by Alberta (57 percent) and Saskatchewan (40 percent). Fertilizer use in the Prairies follows much the same pattern as the soil zones (Figure 8). In general, fertilizers are used on more than 60 percent of improved cropland area in the Black and Gray soil zones (including the Peace River District of Alberta), on 40 to 60 percent in the Dark Brown soil zone, and on less than 40 percent in the more arid Brown soil zone.

In Alberta, 47 CCS report that more than 50 percent of cultivated land receives fertilizers; two of these (Flagstaff County and Cardston County) report using fertilizers on more than 80 percent of cultivated land.

In Saskatchewan, eight CCSs in the arid southern part of the province (Bengough, Enterprise, Val Marie, Cambia, Lone Tree, Cymri, Estevan, Frontier) report using fertilizers on less than five percent of cultivated land. Eleven CCSs in the northern part of Saskatchewan's agricultural land (St. Louis, Willow Creek, Kinistino, Cut Knife, Star City, Ponass Lake, Hillsdale, Flett's Spring, Tisdale, Wallace, Birch Hills) report using fertilizers on more than 75 percent of cultivated land.

In Manitoba, fertilizers are used on more than 50 percent of cultivated land in 98 CCSs; six of these (St. Franois Xavier, Macdonald, Montcalm, Whitewater, Rhineland, Grey) report using them on more than 90 percent of cultivated land. Three CCSs located at the northern edge of Manitoba's agricultural land (Division 19 Unorganized, Mountain South, Sifton) report using fertilizer on less than 30 percent of cultivated land.

Fertilizer use is highest on prairie farms (Table 16):

- with larger improved cropland area
- that grow oilseeds, field crops, or wheat (particularly in Manitoba)
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family corporation
- with sales of $220 to $540 per hectare
- with a computer.

The high fertilizer use in Manitoba is associated with wheat crops (Table 16); fertilizer use for other crops is comparable among the three prairie provinces. The relatively high fertilizer use on cattle farms in Alberta is related to the high nutrient demands of crops grown as feed on these farms, and reflects the importance of the cattle industry in this province.

Manure

Manure is not widely used in the Prairies. Twenty to 30 percent of prairie farms report

using manure, but it is applied to three percent or less of cultivated land (Table 3). In Alberta, only two CCSs (Ponoka Country and Barrhead County) report using manure on more than 10 percent of cultivated land. Although all CCSs in Saskatchewan report manure use, none use it on more than five percent of cultivated land. In Manitoba, manure is used on more than 10 percent of cultivated land in three CCSs (La Broquerie, Hanover, Ste. Anne).

The highest manure use is associated with farms (Table 16):

- with larger improved cropland area
- that have cattle or other livestock
- that grow field crops
- where the farmer does not work off the farm
- organized as a family corporation
- with higher per-hectare sales
- with a computer.

Availability is the key factor affecting manure use in the Prairies. Fifty-seven percent of Alberta farms have livestock (dairy cattle, cattle, and other), of which three percent are dairy farms. Thirty-nine percent of Manitoba farms have livestock, of which five percent are dairy farms. Alberta and Manitoba are roughly comparable in their use of manure. However, Saskatchewan, which reports the lowest manure use in Canada, also has the lowest livestock holdings (22 percent), of which only one percent are dairy farms.

Herbicides

The Prairies are among the areas reporting the highest frequency of herbicide use in Canada (Table 5). The highest use of herbicides corresponds to the Black and Gray soil zones. Highest-use areas in each of the prairie provinces are as follows: i) in Alberta, herbicides are used on more than 60 percent of the cultivated land around Lethbridge (Agricultural Region 2), Calgary (Agricultural Region 3), and to the

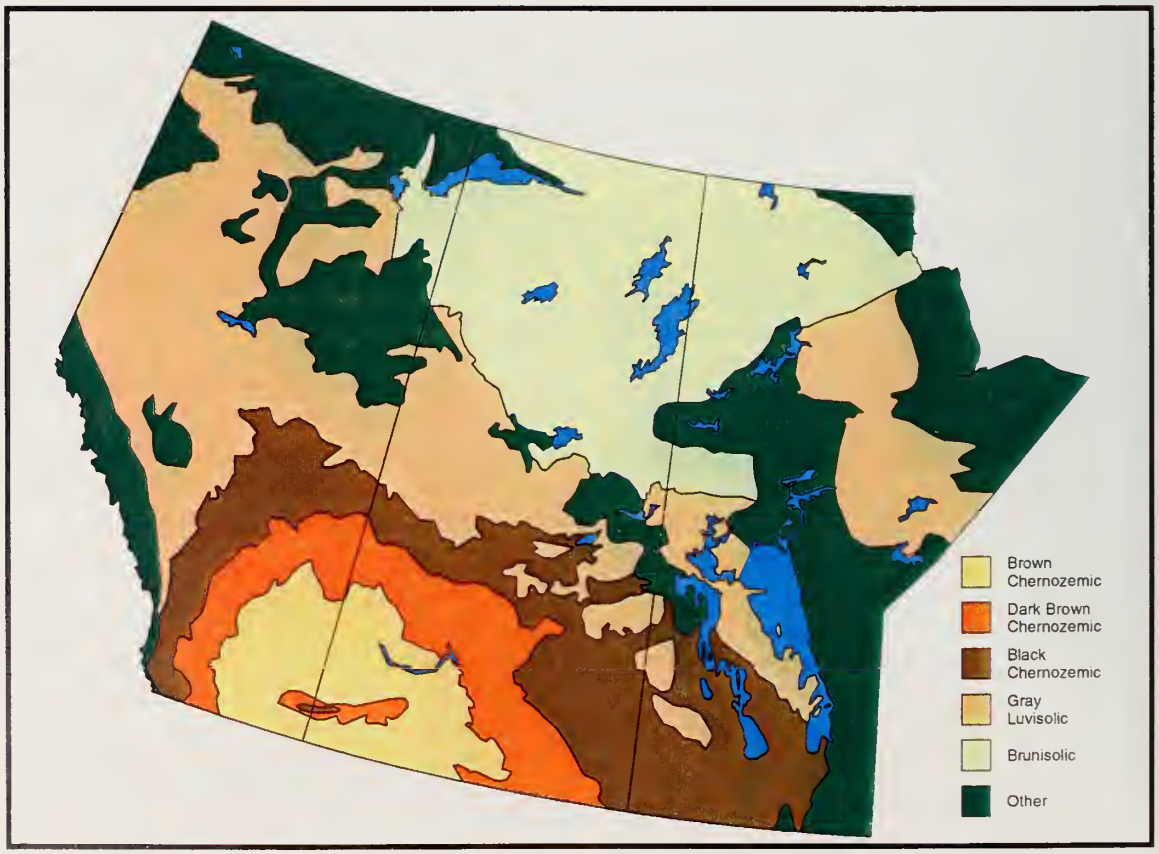

Figure 8. Generalized soil zone map of the Canadian Prairies

Table 16: The use of fertilizers, manure, herbicides, and insecticides in the Prairies, 1991 Census (percent of farms reporting; Alberta, Saskatchewan, and Manitoba, respectively)

Selected Variables		Fertilizer			Manure			Herbicides			Insecticides		
		A	S	M	A	S	M	A	S	M	A	S	M
Improved Cropland (ha)	1–49	32	28	36	20	12	19	17	26	25	3	4	8
	50–125	56	50	64	24	11	25	41	56	53	4	8	12
	126–200	68	56	78	30	14	33	56	68	68	7	11	18
	201–400	77	65	87	32	20	35	68	77	79	9	15	30
	401+	80	70	90	31	23	34	79	82	83	16	22	41
Farm Type	Cattle	51	44	46	37	39	39	37	51	31	4	7	8
	Other Livestock	38	41	47	33	36	45	30	45	43	4	10	13
	Wheat	69	57	84	5	8	10	72	77	76	12	15	24
	Oilseeds	81	80	80	3	4	4	67	71	70	10	16	21
	Hay and Fodder	37	29	35	5	2	5	23	25	26	3	6	13
	Other Field Crops	84	82	87	15	20	29	74	78	81	13	21	34
Days Off-farm Work	None	62	60	70	30	20	32	52	69	61	7	14	21
	1–59	62	63	71	24	18	28	54	75	65	9	17	25
	60–189	54	60	62	20	13	20	43	71	53	6	16	18
	190+	48	52	55	18	10	19	34	63	46	5	11	14
Farm Organization	Family Holding	57	59	66	25	17	28	47	69	57	6	14	19
	Family Corporation	68	68	72	34	18	30	56	73	66	12	20	36
	Non-family Corporation	52	54	48	22	14	16	41	58	38	7	12	13
Sales/ha[1] ($)[2]	1–124	41	36	44	12	9	14	35	57	39	4	10	7
	125–220	63	53	71	19	13	23	55	74	63	7	14	16
	221–320	71	67	82	27	17	28	60	76	72	8	16	24
	321–540	71	76	83	33	20	31	58	77	73	9	17	31
	541+	60	67	64	44	28	46	44	64	52	7	15	22
Computer	Farm with	69	72	80	33	20	34	59	81	75	12	23	37
	Farm without	56	57	65	25	17	27	46	67	56	6	13	18

[1] hectare of improved cropland

[2] Per-hectare sales categories for Saskatchewan are: $1–$99, $100–$150, $151–$200, $201–$275, $276+

east of Edmonton (Agricultural Region 4); ii) in Saskatchewan, herbicides are used on more than 60 percent of the cultivated land around North Battleford (northern Division 13 and southern Divisions 16 and 17), northeast (Division 15) and southeast (northern Divisions 14 and 15) of Saskatoon, and in the eastern portions of Divisions 5 and 9 on the Saskatchewan-Manitoba border; iii) in Manitoba, more than 70 percent of cultivated land receives herbicides on the farmland surrounding and south of Brandon and Winnipeg (Agricultural Regions 1, 2, 3, 7 and 8).

Herbicides are more commonly used on farms (Table 16):

- with greater improved cropland area (herbicide use on farms with more than 400 hectares of improved cropland is more than three times that of farms with less than 50 hectares of improved cropland)
- that grow wheat, oilseeds, or field crops
- where the farmer works off the farm for fewer than 60 days in a year
- organized as a family unit
- with sales of $221 to $540 per hectare
- with a computer.

Insecticides

Insecticides are used on five percent of cultivated land in Alberta and Saskatchewan and on more than twice this share of cultivated land (12 percent) in Manitoba (Table 5). In Alberta, only two CCSs (Taber County and Edmonton) report that more than 10 percent of cultivated land receives insecticides. In Saskatchewan, only Milton reports substantial insecticide use (20 percent of cultivated land). Five CCSs in Manitoba (Montcalm, Dufferin, Franklin,

Taché, St. François Xavier) use insecticides on more than 30 percent of cultivated land.

Insecticides are most commonly used on farms (Table 16):

- with larger improved cropland area (five times greater use on farms with more than 400 hectares of improved cropland compared to farms with less than 40 hectares of improved cropland)
- that grow field crops, wheat, or oilseeds
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family corporation
- with sales of $221 to $540 per hectare
- with a computer (about twice as common as on farms without).

Erosion Control Practices

The terrain, climate, soil, and cultivating history of the Prairies make this region particularly susceptible to erosion. This accounts for the fact that the Prairies, along with Ontario, lead the provinces in the use of grassed waterways, strip-cropping, contour cultivation, and windbreaks to control erosion. Winter cover crops are not important to erosion control in the Prairies, being used at less than the national average in all three provinces (Table 7); stubble mulch and direct seeding are used to maintain cover over the critical periods of spring and fall.

The highest use of forages in rotations (Figure 4) in Alberta is in the area north, southwest, and west of Edmonton (Agricultural Regions 4B, 5, southern portions of 6, and the Peace River District). In Saskatchewan, mainly the northern quarter of agricultural land (Agricultural Regions 5B, 8, and 9) and the extreme southeast corner of the province (portions of Region 1) report using forages on more than 30 percent of cultivated land. High use (used on more than 50 percent of cultivated land) of forages is reported in pockets throughout Manitoba's agricultural land.

The presence of a computer on a farm and the per-hectare sales have little correlation with the use of forages. The use of forages in rotations is more common on farms (Table 17):

- with at least 50 hectares of improved cropland
- that grow hay and fodder or field crops, or have cattle
- where the farmer works off the farm fewer than 190 days in a year
- organized as a family unit.

Alberta reports the highest use of grassed waterways in the country (17 percent, Table 7). This method is used mainly in the western part of the province. Over 90 percent of farmers in three CCSs (two just north of Red Deer, one in the Peace River District) report using grassed waterways.

Grassed waterways are more common on farms (Table 17):

- with larger improved cropland area
- that grow field crops or raise cattle
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family unit
- with sales of $221 to $540 per hectare
- with a computer.

Strip-cropping is commonly reported in Saskatchewan (21 percent of farms), but this is somewhat less in Alberta (10 percent) and Manitoba (five percent) (Table 7). This method is used mainly in the southwestern portion of Saskatchewan (Agricultural Regions 3 and 4 and, to a lesser extent, 1A, 6B and 7). Four CCSs report using strip-cropping on more than 80 percent of cultivated land (one just north of Moose Jaw and three in the southwest, close to the border).

Strip-cropping is more common on farms (Table 17):

- with greater improved cropland area
- that grow wheat
- where the farmer works off the farm fewer than 60 days in a year
- with sales of $125 to $220 per hectare
- with a computer.

Contour cultivation is common in Saskatchewan (18 percent of farms), followed by Manitoba (13 percent) and Alberta (11 percent) (Table 7).

Contour cultivation is most common on farms (Table 17):

- with more than 125 hectares of improved cropland
- that grow wheat, oilseeds, or field crops
- with sales of $125 to $320 per hectare.

Table 17: Erosion control practices in the Prairies, 1991 Census (percent of farms reporting; Alberta, Saskatchewan, and Manitoba, respectively)

Selected Variables		F			GW			SC			CC			WB		
Improved Cropland (ha)	1–49	30	22	25	9	5	5	2	5	3	5	10	8	23	25	25
	50–125	45	22	35	12	6	9	5	14	4	10	16	11	23	26	27
	126–200	47	21	38	16	9	14	8	19	5	12	18	14	24	29	34
	201–400	46	23	37	21	13	16	11	21	5	13	19	14	29	35	43
	401+	36	21	36	23	18	18	23	29	6	13	18	14	37	45	50
Farm Type	Cattle	46	33	40	17	14	10	7	19	4	7	13	6	23	25	19
	Other Livestock	28	24	27	11	9	9	4	12	3	7	12	9	23	30	29
	Wheat	21	11	22	12	10	12	29	27	4	14	20	17	31	36	40
	Oilseeds	36	27	26	14	12	8	4	7	3	16	17	15	27	33	37
	Hay and Fodder	54	52	43	12	8	8	2	5	3	4	4	5	20	25	21
	Other Field Crops[1]	38	32	36	18	17	16	7	11	5	15	17	14	33	40	46
Days Off-farm Work	None	39	21	33	16	12	12	10	21	4	10	17	12	26	33	34
	1–59	41	23	35	18	15	14	11	22	6	10	18	11	29	39	40
	60–189	42	23	29	14	12	10	6	19	3	10	17	12	24	36	33
	190+	36	20	30	12	9	9	5	19	4	9	17	10	24	32	30
Farm Organization	Family Holding	39	21	32	15	12	11	8	20	4	10	17	12	25	34	33
	Family Corporation	36	20	32	18	18	14	11	22	5	10	14	10	35	46	44
	Non-family Corporation	26	17	21	11	8	7	10	16	6	8	16	10	25	32	29
Sales/ha[2] ($)[3]	1–124	39	18	32	12	8	9	10	24	4	10	17	10	21	27	24
	125–220	41	19	36	16	12	13	13	29	5	12	20	14	25	34	31
	221–320	42	20	35	18	13	15	9	23	5	12	19	14	29	35	39
	321-540	42	25	34	18	15	14	7	16	4	11	17	12	30	39	43
	541+	41	27	33	14	12	9	5	12	4	8	14	10	27	37	35
Computer	Farm with	39	23	34	21	18	18	11	25	6	10	16	11	36	49	53
	Farm without	38	21	32	14	11	11	8	20	4	10	17	12	24	32	32

[1] Other field crops do not include potatoes

[2] hectare of improved cropland

[3] Sales/ha categories for Saskatchewan are: $1–$99, $100–$150, $151–$200, $201–$275, $276+

F = Forages in rotations, GW = Grassed Waterways, SC = Strip-cropping, CC = Contour Cultivation, WB = Windbreaks

Windbreaks, or shelterbelts, are used on 29 percent of Alberta farms, 35 percent of Saskatchewan farms, and 37 percent of Manitoba farms (Table 7). In Alberta, more than 30 percent of farmers use windbreaks in four CCSs (Edmonton, Paintearth County, Lacombe County, Calgary). In Saskatchewan, windbreaks are used by more than 50 percent of farmers in five CCSs (Bone Creek, Grandview, Victory, Canaan, Fertile Valley).

Windbreaks are more common on farms (Table 17):

- with larger improved cropland area
- that grow field crops, wheat, or oilseeds
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family corporation
- with sales of $321 to $540 per hectare
- with a computer.

Salinity Control

Soil salinity is a problem only on the Prairies. Common methods to control salinity include continuous cropping, planting alfalfa, reverting to permanent pasture, and improving drainage systems to eliminate excess water.

Thirteen percent of Alberta farms, 25 percent of Saskatchewan farms, and 16 percent of Manitoba farms report taking measures to control soil salinity. In Alberta, more than 30 percent of farmers use salinity controls in six CCSs (Wheatland County, Forty Mile County, Vulcan County, Newell County, Taber County, Warner County). Saskatchewan is the only province in which all CCSs report salinity con-

Soil Salinity

Salts are concentrated at or near the soil surface in saline soils, due to water moving upward with evaporation. The salts are evident by the white crust ("white alkali") that may appear on the soil surface when dry.

An estimated 1.2 to 1.4 million hectares of land in the Canadian Prairies are moderately to severely affected by salinity. Yields of cereal crops may be reduced by 50 to 100 percent in areas with severe salinity.

Crop production on saline soil may be improved by incorporating animal or green manure, growing salt-tolerant crops, and improving surface and subsoil drainage. Saline areas should be cropped continuously with long-term forages, like alfalfa, which prevent deep percolation of salt- laden water below the root zone and loss of water by evaporation from the surface.

Current salinity research involves studying the effects of changes in cropping systems and climate, identifying groundwater recharge and discharge areas, determining crop tolerance levels, and developing a system to predict soil salinity.

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trols. More than 50 percent of farmers use salinity controls in 11 CCSs (Norton, Big Arm, Enterprise, Mariposa, Willow Bunch, Happyland, Grassy Creek, Maple Bush, Wreford, Mankota, Wise Creek). In Manitoba, more than 40 percent of farmers report using salinity controls in six CCSs (Winchester, Brenda, Whitewater, Glenwood, Morton, Cameron).

Salinity controls are more common on farms (Table 18):

- with larger improved cropland area
- that grow wheat or field crops
- where the farmers works off the farm fewer than 60 days in a year
- organized as a family corporation
- with sales of more than $124 per hectare
- with a computer.

Weed Control Methods on Summerfallow

More than 98 percent of summerfallow in Canada is found in the Prairies. Summerfallow makes up 28 percent of improved cropland in Saskatchewan, 14 percent in Alberta, and six percent in Manitoba (Figure 9; Table 9).

The low supply and unpredictable occurrence of precipitation during the growing season are most likely to limit crop production in the Prairies. The main goal of using summerfallow in this region is the conservation of soil moisture — producers feel obliged to use this technique as an "insurance policy" against crop failure. Summerfallow is used to a lesser extent in humid areas to control some weeds and diseases. Weeds on summerfallow can be controlled with periodic tillage, chemicals, or combinations of the two.

In Alberta, combination (chemicals plus tillage) weed control is used on more than 50 percent of summerfallow in seven CCSs (Kneehill County, Fairview County, Rocky View County, Special Area #3, Smoky River County, Vulcan County, Pincher Creek County).

In Saskatchewan, 43 CCSs report using combination weed control on more than 50 percent of summerfallow, and two of these use this method on more then 70 percent of summerfallow.

Manitoba reports the lowest use in Canada of chemicals only (three percent) and the highest use in the Prairies of tillage only (73 percent) to control weeds on summerfallow (Table 9). Only three CCSs report using combination weed control on more than 40 percent of summerfallow.

Effects of Summerfallow

Summerfallow is a cropping practice used mostly in semi-arid areas, whereby land is rested for one growing season to enhance soil water and thereby provide some insurance against crop failure

Positive	Negative
• buffers against drought, stabilizes yield	• uses a small portion of precipitation over two-year crop cycles (inefficient use)
• increases net returns, reduces financial risk	• increases the risk of soil erosion and nutrient losses by leaching
• breaks disease and insect cycles	• increases soil salinity
• provides "acres" for delivery quotas	• decreases soil organic matter
• reduces nitrogen (N) fertilizer requirements in the short term	• destroys soil structure

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Table 18: Salinity control in the Prairies, 1991 Census (percent of farms reporting)

Selected Variables		Alberta	Saskatchewan	Manitoba
Improved Cropland (ha)	1–49	4	9	5
	50–125	8	13	10
	126–200	11	18	15
	201–400	15	26	22
	401+	25	38	30
Farm Type	Cattle	10	21	11
	Other Livestock	7	19	10
	Wheat	18	26	18
	Oilseeds	10	17	12
	Hay and Fodder	7	13	7
	Other Field Crops	15	29	23
Days Off-farm Work	None	13	25	17
	1–59	14	32	16
	60–189	9	24	13
	190+	8	19	9
Farm Organization	Family Holding	11	24	15
	Family Corporation	21	31	23
	Non-family Corporation	14	25	6
Sales/ha[1] ($)[2]	1–124	7	19	9
	125–220	12	27	17
	221–320	13	27	20
	321–540	14	27	20
	541+	13	23	12
Computer	Farm with	18	37	25
	Farm without	10	23	14

[1] hectare of improved cropland

[2] Sales/ha categories for Saskatchewan are: $1–$99, $100–$150, $151–$200, $201–$275, $276+

A comparison of weed control practices (Table 19) shows:

- as summerfallow area increases:
  - chemical-only weed control increases two times (Manitoba), three times (Saskatchewan), or four times (Alberta) on farms with the most summerfallow compared to farms with the least summerfallow
  - tillage-only weed control decreases in Alberta and Saskatchewan and stays the same in Manitoba
  - combination (chemical plus tillage) weed control increases (use on farms with the most summerfallow is double that on farms with the least summerfallow in Alberta and Saskatchewan, and about half in Manitoba)
- tillage only is more likely used on family holdings, whereas chemicals only and combination weed control are more likely used by family corporations
- combination (chemical plus tillage) weed control is used more on farms with a computer; tillage only is used more on farms without a computer.

Despite the benefits of summerfallow, this practice contributes to soil degradation. Research in Saskatchewan has demonstrated three ways to eliminate or reduce the negative effects of summerfallow:

1) Stubble management techniques at harvest time can enhance the trapping of snow, which increases the amount of water

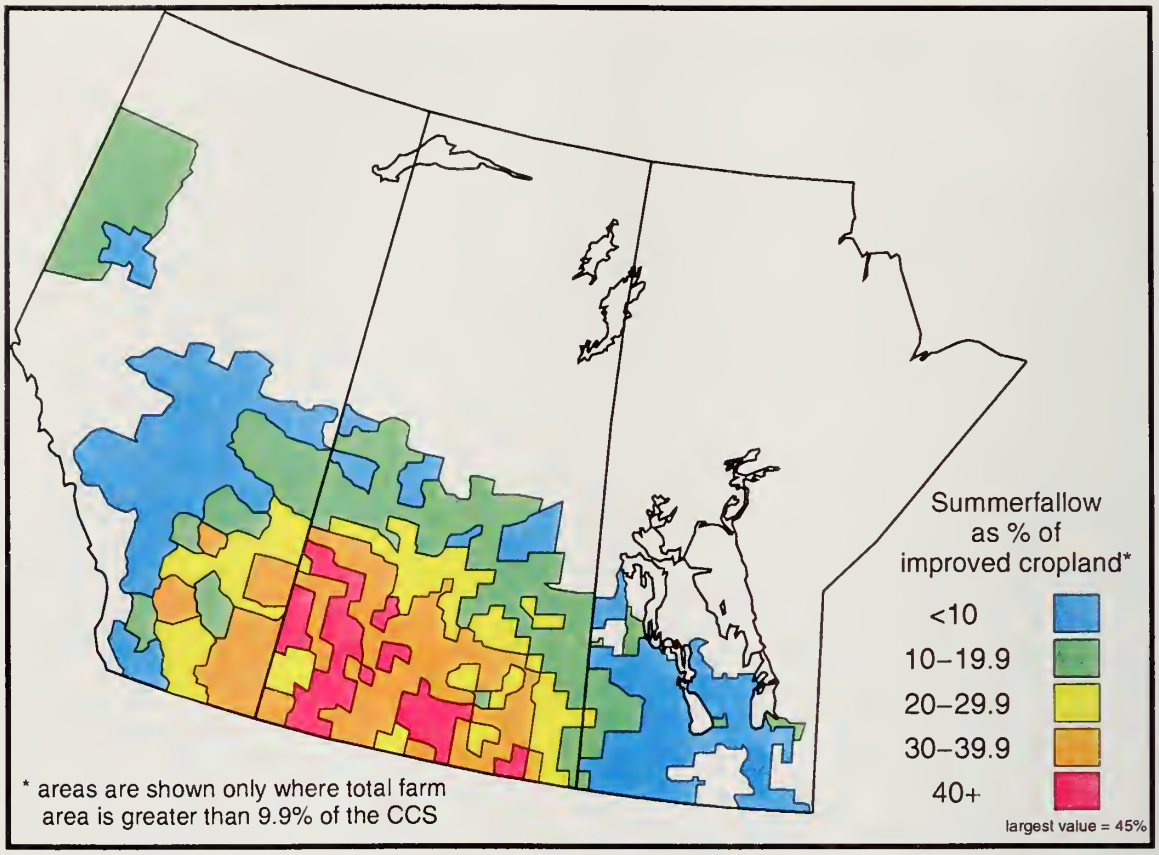

Figure 9. Summerfallow as a percent of improved cropland.

Table 19: Weed control practices on summerfallow in the Prairies, 1991 Census (percent of farms reporting; Alberta, Saskatchewan, and Manitoba, respectively)

Selected Variables		Chemical			Tillage			Chemical + Tillage		
Summerfallow (ha)	1–14	3	4	3	78	73	79	22	25	21
	15–50	4	4	3	68	69	77	33	31	25
	51–110	5	6	5	62	67	77	44	37	30
	111–200	8	8	7	63	65	76	47	43	30
	201+	14	13	6	65	60	78	50	54	32
Days Off-farm Work	None	2	6	1	25	52	24	14	31	8
	1–59	2	7	1	24	48	21	16	34	8
	60–189	2	5	1	20	46	21	11	30	7
	190+	1	4	1	16	44	18	7	25	6
Farm Organization	Family Holding	2	5	1	22	50	23	12	29	7
	Family Corporation	3	9	2	20	40	16	17	40	9
	Non-family Corporation	2	8	1	17	44	24	14	27	9
Sales/ha[1] ($)[2]	1–124	3	6	2	30	55	34	13	27	8
	125–220	3	7	2	33	59	35	19	35	12
	221–320	2	6	1	26	55	25	16	36	9
	321–540	1	5	1	18	48	16	12	33	7
	541+	1	3	1	11	35	14	5	21	4
Computer	Farm with	2	7	1	19	43	16	16	41	10
	Farm without	2	5	1	23	50	23	12	28	7

[1] hectare of improved cropland

[2] Sales/ha categories for Saskatchewan are: $1–$99, $100–$150, $151–$200, $201–$275, $276+

that can be stored by the soil. This reduces the need for summerfallow.

2) Exclusive use of herbicides for weed control on summerfallow is less degrading to the soil than tillage. As effective herbicides (eg., glyphosate, "Round-Up") become less expensive, this practice will become more popular. However, the possible negative effects on wildlife habitat and water quality must also be considered.
3) Measurements of soil moisture in the spring and of precipitation during the early growing season provide a guide to whether land should be recropped or summerfallowed (flex cropping).

Tillage Practices Used to Prepare Land for Seeding

The prairie provinces lead the country in the use of conservation tillage (Table 11). In Alberta, 15 CCSs report using conservation tillage or no-till on more than 30 percent of land prepared for seeding. In Saskatchewan, conservation tillage or no-till is used on more than 50 percent of land prepared for seeding in 37 CCSs; in seven of these (Dundurn, Bratt's Lake, Lajord, Pense, Sherwood, Pittville, Prairiedale), conservation tillage or no-till is used on more than 70 percent of land prepared for seeding (Saskatchewan reports the highest use of no-till: 10 percent of seeded land). In Manitoba, 18 CCSs report using conservation tillage or no-till on more than 40 percent of land prepared for seeding.

A comparison of tillage practices (Table 20) shows:

- between the smallest and largest areas of cropland:
  - the use of conventional tillage increases 10 to 20 percent
  - the use of conservation tillage increases by two to three times
  - the use of no-till increases by three to four times

Conservation Tillage Catches On

Record numbers of prairie farmers are using conservation tillage methods. A recent survey by the Prairie Farm Rehabilitation Administration (PFRA) comparing 1993 tillage practices in Alberta and Saskatchewan with those used five years earlier shows an increase in fields with standing and partially standing stubble, residue on cropped fields, and forages.

Conservation tillage is a term that covers a range of practices that use less tillage and leave more of the previous year's crop residue on the field. Usually the amount of tillage required is determined by the soil type, climate, and crop. In semi-arid climates like the Prairies, conservation tillage is used to keep at least 30 percent of the soil surface covered by crop residue.

Maintaining high levels of crop residue or stubble on fields has many benefits:

- protecting against wind and water erosion
- trapping snowfall
- conserving soil moisture
- providing a protective canopy for the growing crop
- maintaining soil organic matter
- providing nesting cover for waterfowl

Conservation tillage has the added benefit of reducing farm input costs, including energy and time.

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- conservation tillage is associated with wheat and, to a lesser extent, field crops and oilseeds; no-till is associated with wheat and, to a lesser extent, field crops
- conservation tillage and no-till are more commonly used by family corporations, whereas conventional tillage is more commonly used on family holdings
- conservation and no-till are more likely used by farms with a computer; conventional tillage is more likely used by farms without a computer.

Table 20: Tillage practices used to prepare land for seeding in the Prairies, 1991 Census (percent of farms reporting; Alberta, Saskatchewan, and Manitoba, respectively)

Selected Variables		Conventional Tillage			Conservation Tillage			No-till		
Improved Cropland (ha)	1–39	50	63	49	9	16	11	2	6	4
	40–100	73	72	69	14	21	19	3	9	5
	101–200	82	74	74	18	26	27	3	11	7
	201–300	81	73	75	24	30	32	5	15	9
	301+	76	70	73	32	35	39	8	20	15
Farm Type	Wheat	76	71	74	28	29	30	8	16	9
	Oilseeds	86	82	77	18	25	24	3	6	7
	Hay and Fodder	46	34	39	8	9	10	4	6	3
	Other Field Crops	83	77	75	24	29	33	4	12	11
Days Off-farm Work	None	68	70	66	19	27	25	4	12	7
	1–59	67	69	65	18	27	26	5	17	9
	60–189	63	70	59	14	25	21	3	13	7
	190+	55	65	53	11	22	17	3	12	5
Farm Organization	Family Holding	65	70	63	16	26	23	3	12	7
	Family Corporation	63	63	59	24	32	33	6	20	12
	Non-family corporation	56	64	52	17	22	18	6	14	7
Sales/ha[1] ($)[2]	124	65	69	63	15	23	18	4	12	5
	125–220	72	71	71	20	27	25	4	15	8
	221–320	74	72	72	20	29	29	4	14	8
	321–540	71	73	68	18	29	30	3	13	9
	541+	62	68	59	13	24	20	3	10	6
Computer	Farm with	63	65	61	22	34	37	5	21	13
	Farm without	65	69	63	15	25	22	3	12	7

[1] hectare of improved cropland

[2] Sales/ha categories for Saskatchewan are: $1–$99, $100–$150, $151–$200, $201–$275, $276+

CENTRAL CANADA (Ontario and Quebec)

Province	No. of Farms (thousands)	Total Farm Area (million ha)	Average Farm Size (ha)	Improved Cropland Area (million ha)	Percent Improved Cropland	No. of CCSs*	No. of CCSs* reporting agricultural activity
Ontario	68.6	5.5	80	3.9	71	484	436
Quebec	38.1	3.4	90	1.9	56	103	97

* Divisions, for Quebec

Ontario has the most farms of all the provinces, but the farms are comparatively small (only Newfoundland has smaller farms). A relatively high proportion of Ontario farmland is improved cropland (only slightly lower than Saskatchewan). Improved cropland makes up more than 50 percent of farmland in 323 CCSs, and more than 95 percent of farmland in 10 of these CCSs (almost all located in the extreme southwest of the province, Figure 1).

In Quebec, land management practices are summarized at the Division level because of the large number of CCSs. Improved cropland makes up more than 50 percent of farmland in 55 Divisions, mainly south of the St. Lawrence River (Figure 1). Ten of these divisions, mainly located in Region 6 (the area surrounding and south of St. Hyacinthe), report that more than 80 percent of farmland is improved cropland.

Fertilizers

All agricultural areas in Ontario and Quebec report the use of fertilizers. Fertilizers are used on more than 50 percent of cultivated land in 263 Ontario CCSs (mainly east of Ottawa, west of Kingston, and south of Barrie). Fifty-five Quebec Divisions, almost all located south of the St. Lawrence River, use fertilizers on more than 50 percent of cultivated land. In Quebec, much of Agricultural Regions 3, 4, and 6 (south of the St. Lawrence River, surrounding Saint Georges, Drummondville, and Saint Hyacinthe) report fertilizer use on more than 60 percent of cultivated land. Fertilizers are used on more than 75 percent of cultivated land in much of southern Ontario (six Ontario CCSs report that more than 90 percent of cultivated land receives fertilizer).

Fertilizer use in Ontario and Quebec is highest on farms (Table 21):

- with larger improved cropland area (twice as high on farms with more than 90 hectares of improved cropland compared to those with less than 18 hectares of improved cropland)
- that grow grain corn or sunflowers, field beans or peas, or other field crops
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family unit
- with higher per-hectare sales, peaking at sales of $1501 to $2700 per hectare
- with a computer.

Manure

Ontario and Quebec report relatively high use of manure compared to the other provinces (Figure 10; Table 3). In Ontario, manure is used in all but one CCS, and five CCSs (Monmouth,

Continuous Corn

Haldimand-Norfolk, an agricultural area south of Ontario's Niagara Peninsula, is dominated in the west by highly erodible sandy soils and in the east by poorly drained, fine-textured clays. About half the area is cropped, and an increasing share was used for corn production until the early 1980s. In spite of this, corn yields decreased during that period, indicating that continuous corn production may contribute to soil degradation.

In the past decade, cropping to corn has decreased in this area. A survey conducted under the National Soil Conservation Program found that the area planted to corn in 1991 was only one third of that used for this crop in 1990. However, about 28 per cent of the more vulnerable clay soils were cropped in both years. Research results indicate that including different crops in rotation will improve soil quality and crop productivity.

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Table 21: The use of fertilizers, manure, herbicides, and insecticides in central Canada, 1991 Census (percent of farms reporting; Ontario and Quebec, respectively)

Selected Variables		Fertilizers		Manure		Herbicides		Insecticides	
Improved Cropland (ha)	1–17	44	39	39	43	27	23	20	19
	18–35	63	54	53	60	42	32	16	12
	36–60	76	69	62	74	58	45	20	9
	61–90	84	78	71	81	71	58	23	8
	91+	89	81	70	78	79	65	31	10
Farm Type	Dairy	85	80	91	89	74	55	19	5
	Cattle	57	40	75	71	33	13	8	2
	Other Livestock	47	29	60	52	34	23	14	5
	Grain Corn and Sunflowers	90	90	17	23	78	83	34	19
	Field Beans/Peas	85	91	11	7	78	73	18	24
	Hay and Fodder	39	33	20	26	19	17	5	4
	Other Field Crops	90	79	38	33	76	65	43	23
Days Off-farm Work	None	68	61	58	65	54	43	23	11
	1–59	69	42	53	46	55	27	24	11
	60–189	62	38	51	44	45	23	19	10
	190+	57	36	47	37	39	21	15	9
Farm Organization	Family Holding	64	54	54	58	48	36	19	10
	Family Corporation	73	66	55	66	62	54	37	14
	Non-family Corporation	53	43	34	37	41	33	27	16
Sales/ha[1] ($)	1–299	48	35	47	51	25	15	7	4
	300–625	68	52	53	60	48	27	13	7
	626–1500	78	72	58	70	64	49	22	10
	1501–2700	82	81	76	81	71	62	30	12
	2701+	71	63	58	62	58	49	41	23
Computer	Farm with	70	64	55	64	59	52	30	15
	Farm without	64	54	54	57	48	36	19	10

[1] hectare of improved cropland

Thunder Bay, Dalton, Bracebridge, South Sherbrooke) report using manure on more than 50 percent of cultivated land. In nine CCSs (South Sherbrooke; Clarendon and Miller; Laxton, Digby, Longford; Bagot and Blythfield; Gravenhurst; Front of Escott; Huntsville; Oso; Hinchinbrooke), twice as much cropland receives manure as receives fertilizers.

All Quebec Divisions report using manure; in 23 Divisions more than 50 percent of cultivated land receives manure, and five of these (Coaticook, La Haute Yamaska, Charlevoix, La Nouvelle Beauce, Le Haut Saint Maurice) reported 60 percent use. Manure is used on a larger area of cultivated land than receives fertilizer in 23 Divisions; four of these (Charlevoix, Charlevoix Est, Le Haut Saint Maurice, La Nouvelle Beauce) apply manure to twice the area receiving fertilizer.

Manure is more commonly applied to the cropland of farms (Table 21):

- with larger improved cropland area (almost twice as high on farms with more than 90 hectares of improved cropland compared to those with less than 18 hectares of improved cropland)
- with dairy or other cattle
- where the farmer does not work off the farm
- organized as a family unit
- with higher per-hectare sales, peaking at sales of $1501 to $2700 per hectare.

Herbicides

All but six Ontario CCSs report using herbicides. Herbicides are used on more than 50 percent of the cultivated land in 133 CCSs, found mainly in southwestern Ontario. Ten CCSs (Anderdon, East Williams, Zone, Aldborough, Dover, Chatham, West Williams, Howard, Euphemia, Pelee) report herbicide use on more than 80 percent of cultivated land.

Quebec farms report the use of herbicides at less than the Canadian average (Table 1); herbicides are used on more than 60 percent of cultivated land in only 12 Divisions (Laval, Montcalm, Le Bas Richelieu, Rouville, Rousillon, Les Jardins de Napierville, La Valle du Richelieu, Vaudreuil-Soulages, Les Pays d'en Haut, Beauharnois-Salaberry, Le Haut Richelieu, Les Maskoutains).

Herbicides are more commonly used on farms (Table 21):

- with greater improved cropland area (almost three times as high on farms with more than 90 hectares of improved cropland compared to those with less than 18 hectares of improved cropland)
- that grow grain corn and sunflowers, field beans and peas, and other field crops
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family corporation
- with higher per-hectare sales, peaking at sales of $1500 to $2700 per hectare
- with a computer.

Insecticides

In Ontario, insecticide use is localized; three CCSs in the southwestern part of the province (Lincoln, Niagara on the Lake, St. Catharines) report using insecticide on more than 40 percent of cultivated land. This practice is less important in Quebec (Table 5), where insecticide is used on more than 30 percent of cultivated land in only one Division (Laval).

Insecticides are more likely used on farms (Table 21):

- that grow field crops

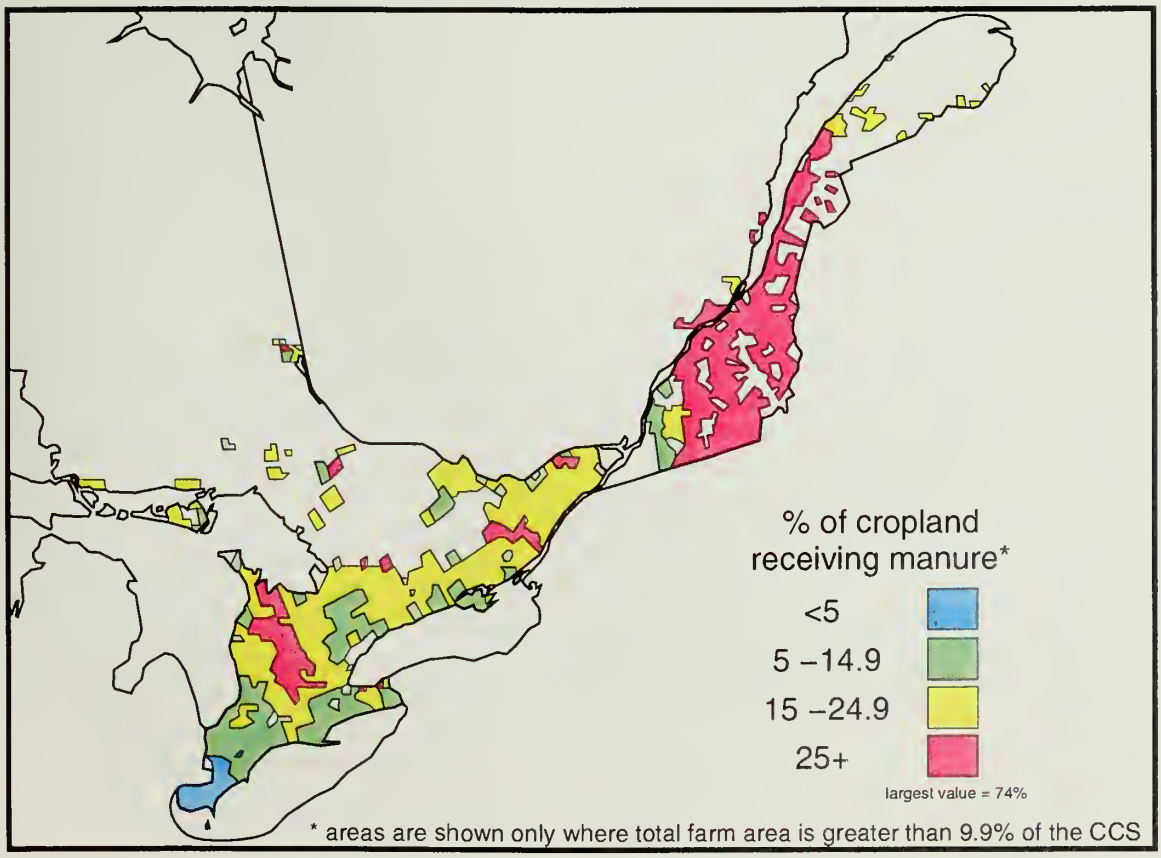

Figure 10. Percent of improved cropland receiving manure.

- where the farmer works off the farm fewer than 60 days in a year
- organized as a family corporation
- with higher per-hectare sales (six times higher on farms with sales of more than $2700 per hectare compared to those with sales of less than $300 per hectare)
- with a computer.

Erosion Control Practices

Ontario and Quebec report a high use of forages in crop rotations. Ontario leads the country in the use of winter cover crops and also reports high use of windbreaks (Table 7).

All Ontario CCSs report using forages in crop rotations; more than half the farmers use this method in 300 CCSs and more than 80 percent of farmers use this method in 10 of these (Downie, South Easthorpe, Greenock, Nichol, Mornington, Stafford, Adolphustown, Wallace, Carrick, Matchedash). All but 22 CCSs report the use of winter cover crops; in eight CCSs (Mosa, Simcoe, Yarmouth, Oakland, Malahide, Bayham, Delhi, Norfolk) more than 40 percent of farmers use this erosion control method. More than 40 percent of farmers use windbreaks in one CCS (Delhi) and grassed waterways in three CCSs (Westminster, Yarmouth, South Dorchester).

Forages are used in crop rotations in all Quebec regions. This method is used by more than half the farmers in 42 divisions and by more than 65 percent of farmers in seven of these Divisions (Francheville, Nicolet Yamaska, Rivière du Loup, Mekinac, Kamouraska, Les Basques, Bécancour). Grassed waterways are used by 20 percent of farmers in Les Pays d'en Haut, and shelterbelts are used by 21 percent of farmers in Manicouagan.

All erosion control practices are more commonly used on Ontario and Quebec farms (Table 22):

- with larger improved cropland area (on farms with over 90 hectares of improved cropland compared to farms with less than 18 acres of cropland: the use of forages in rotations is twice as high, the use of winter cover crops is three and a half times as high, the use of grassed waterways is two and a half times as high, the use of contour cultivation is twice as high, and the use of windbreaks is slightly higher)
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family corporation (or as a family holding in the case of using forages in rotations)
- with a computer (although there is little difference between farms with and without a computer in the use of forages in rotations).

The use of forages in rotations, winter cover crops, and grassed waterways increases as per-hectare sales increase, and peaks on farms with sales of $1501 to $2700 per hectare (the use of forages increases by one and a half times, the use of winter cover crops increases by two and a half times, and the use of grassed waterways doubles). Sales have little effect on the use of contour cultivation and windbreaks.

Tillage Practices Used to Prepare Land for Seeding

Ontario farms report preparing more than 2.5 million hectares of cropland for seeding in 1991. Three hundred and eighty-six CCSs report using conventional tillage methods on more than half the area prepared for seeding; four of these report using these methods on all land prepared for seeding. Quebec farms report preparing about 850 thousand hectares for seeding. Eighty-seven Divisions report using conventional tillage methods; 86 Divisions report using these methods on more than half the seeded cropland.

Conservation tillage methods (Figure 7) are used more in Ontario than in Quebec (18 percent versus 12 percent of seeded cropland, Table 11). In Ontario, 156 CCSs report using conservation tillage or no-till on more than 20 percent of land prepared for seeding; five of these (Oxford; Haldimand; Zone; Parry Sound, Unorganized, Centre; Cramahe) prepare more than 50 percent of seeded land using these methods.

In Quebec, only three Divisions (Charlevoix Est, Rouyn Noranda, La Côte de Beaupré) report using conservation tillage or no-till on more than 25 percent of seeded cropland.

A comparison of the three tillage practices (Table 23) shows:

- the use of conventional tillage is almost twice as high, and the use of conservation

tillage is about three times as high, on farms with more than 90 hectares with improved cropland compared to those with less than 18 hectares of cropland

- the use of conservation tillage increases at a greater rate than conventional tillage as per-hectare sales increase (conservation tillage more than doubles, peaking at sales of $1501 to $2700 per hectare, while conventional tillage increases by up to 25 percent, peaking at the same sales level); the use of no-till is not clearly linked to per-hectare sales
- farms with a computer are more likely to use conservation and no-till methods, whereas conventional tillage is practised at similar levels by farms with or without a computer.

Table 22: Erosion control practices in central Canada, 1991 Census (percent of farms reporting; Ontario and Quebec, respectively)

Selected Variables		F		WCC		GW		CC		WB	
Improved Cropland (ha)	1–17	28	24	10	4	9	1	5	3	16	9
	18–35	54	42	15	3	11	4	6	4	16	7
	36–60	66	56	19	3	14	4	7	3	19	6
	61–90	75	66	23	4	18	4	8	4	19	7
	91+	78	65	32	5	23	4	9	4	27	10
Farm Type	Dairy	84	71	18	3	19	4	7	4	9	3
	Cattle	57	39	11	2	13	3	5	4	8	2
	Other Livestock	42	23	13	3	12	3	5	2	12	3
	Silage Corn	86	75	21	4	20	4	8	3	16	7
	Grain Corn and Sunflowers	51	30	22	5	16	5	9	3	19	4
	Field Beans/Peas	60	33	24	6	11	4	7	2	17	4
	Other Field Crops	65	47	49	9	17	6	9	4	27	10
Days Off-farm Work	None	56	48	19	3	14	4	6	3	12	4
	1–59	57	34	21	4	16	4	6	4	16	5
	60–189	52	31	18	3	14	3	6	3	14	5
	190+	48	27	14	2	12	3	6	2	13	4
Farm Organization	Family Holding	54	42	17	3	13	3	6	3	12	4
	Family Corporation	54	48	28	5	20	5	8	4	20	6
	Non-family Corporation	36	27	18	4	12	3	6	3	10	7
Sales/ha[1] ($)	1–299	48	35	10	3	10	3	5	4	10	4
	300–625	59	42	17	3	14	4	7	4	12	4
	626–1500	65	55	22	4	16	4	7	4	14	4
	1501–2700	70	66	24	4	19	5	7	4	14	4
	2701+	44	40	23	5	15	5	6	3	17	7
Computer	Farm with	56	52	25	6	21	6	8	5	21	9
	Farm without	53	42	17	3	13	3	6	3	12	3

[1] hectare of improved cropland

F = Forages in rotations, WCC = Winter Cover Crops, GW = Grassed Waterways, CC = Contour Cultivation, WB = Windbreaks

Table 23: Tillage practices in central Canada, 1991 Census (percent of farms reporting; Ontario and Quebec, respectively)

Selected Variables		Conventional Tillage		Conservation Tillage		No-till	
Improved Cropland (ha)	1–14	46	57	6	7	4	4
	15–30	68	70	10	7	5	4
	31–50	82	82	14	8	6	4
	51–80	87	89	19	12	6	4
	81+	89	92	33	19	12	5
Farm Type	Dairy	90	89	18	9	6	4
	Cattle	60	57	9	5	4	4
	Other Livestock	50	40	10	7	5	2
	Grain Corn and Sunflowers	81	92	32	22	9	5
	Field Beans/Peas	89	91	19	20	8	6
	Hay and Fodder	43	52	5	5	4	2
	Other Field Crops	86	93	32	23	11	6
Days Off-farm Work	None	69	70	16	10	6	4
	1–59	68	53	17	9	7	4
	60–189	63	50	13	7	6	3
	190+	58	45	10	5	5	3
Farm Organization	Family Holding	65	64	14	8	5	3
	Family Corporation	68	71	23	14	9	4
	Non-family Corporation	52	44	13	11	5	3
Sales/ha[1] ($)	1–299	58	60	8	6	5	4
	300–625	71	70	14	7	6	4
	626–1500	78	82	20	11	7	4
	1501–2700	81	86	19	12	7	4
	2701+	63	68	15	11	5	4
Computer	Farm with	65	68	20	15	9	4
	Farm without	65	63	13	8	5	3

[1] hectare of improved cropland

ATLANTIC CANADA (New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland)

Province	No. of Farms (thousands)	Total Farm Area (thousand ha)	Average Farm Size (ha)	Improved Cropland Area (thousand ha)	Percent Improved Cropland	No. of CCSs	No. of CCSs reporting agricultural activity
New Brunswick	3.3	376	115	149	40	107	93
Nova Scotia	4.0	397	100	138	35	54	43
Prince Edward Island	2.4	259	110	174	67	69	61
Newfoundland	0.7	47	65	11	23	85	17

In New Brunswick, improved cropland makes up more than 50 percent of total farm area in 13 CCSs, and more than 60 percent of total farm area in three of these CCSs. In Nova Scotia, more than 50 percent of farmland is improved cropland in only two CCSs. Only Newfoundland has a lower intensity of land conversion than Nova Scotia (35 percent and 23 percent, respectively). In contrast, Prince Edward Island has a high conversion ratio (63 percent), with 53 CCSs reporting more than 50 percent improved cropland and six of these reporting more than 80 percent improved cropland. Newfoundland has the smallest number of farms, the smallest farms, and the lowest cropland conversion in Canada. Many land management practices reported in the 1991 census are not applicable to Newfoundland because of the low cropland ratio.

Fertilizers

All but two New Brunswick agricultural CCSs report fertilizer use. Fertilizers are used on more than 50 percent of cultivated land in 62 CCSs; in nine of these (Wellington, Wilmot, Wicklow, Saint André, Glenelg, Drummond, Southesk, Saint Quentin, Gladstone) fertilizers are used on more than 80 percent of cultivated land.

All Nova Scotia agricultural CCSs report fertilizer use, and more than three-quarters of the cultivated land in this province receives fertilizer. Fertilizers are used on more than 50 percent of cultivated land in 38 CCSs; 12 of these (Guysborough, Kings Subdivision C, Antigonish Subdivisions A and B, Lunenburg, East Hants, Yarmouth, Chester, Colchester Subdivision C, Halifax Subdivision E, Annapolis Subdivision D, Inverness Subdivision B) use fertilizer on more than 90 percent of cultivated land.

All Prince Edward Island agricultural CCSs report fertilizer use. Fifty-four CCSs report using fertilizers on more than 50 percent of cultivated land; three of these (Prince County, Lot 25; North River; Kings County) report using them on more than 80 percent of cultivated land.

Newfoundland reports fertilizer use in all CCSs. In 15 CCSs fertilizers are used on more than 50 percent of cultivated land; four of these (Division 1, Subdivision W; Division 2, Subdivision E; Division 7, Subdivision E; Division 8, Subdivision G) use it on all cultivated land.

Fertilizers are most commonly used on farms (Table 24):

- with larger improved cropland area (the use of fertilizers is about 40 percent higher on farms with more than 70 hectares of cropland compared to farms with less than 10 hectares of cropland)
- that grow potatoes (over 90 percent use in all provinces, except Newfoundland) or have dairy cattle (about 85 percent)
- where the farmer does not work off the farm
- organized as a family unit
- with higher per-hectare sales, peaking at sales of $1301 to $2300 per hectare (except for Newfoundland, whose fertilizer use peaks at sales of $601 to $1300 per hectare)
- with a computer (no difference for Newfoundland).

Table 24: The use of fertilizers, manure, herbicides, and insecticides in the Atlantic provinces, 1991 Census (percent of farms reporting; New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland, respectively)

Selected Variables		Fertilizers				Manure				Herbicides				Insecticides			
Improved Cropland (ha)[1]	1–9	47	50	53	56	42	40	54	46	21	23	25	19	21	21	16	23
	10–20	60	62	66	73	60	59	68	53	18	25	42	24	14	16	18	27
	21–40	66	75	82	79	67	69	76	63	24	27	55	28	15	15	26	32
	41–70	76	84	86	83	75	83	80	54	28	30	66	17	16	16	31	22
	71+	86	91	92	85	64	84	71	46	56	56	80	15	38	26	50	7
Farm Type	Dairy	81	86	85	72	89	90	91	87	27	32	58	9	5	7	15	5
	Cattle	60	69	59	60	76	79	75	65	13	14	33	6	4	5	7	6
	Other Livestock	28	35	53	21	46	49	63	38	7	13	39	2	3	10	13	2
	Potato	92	92	90	71	28	54	51	18	79	73	75	41	83	73	76	35
Days Off-farm Work	None	63	65	75	56	54	60	68	42	30	28	56	17	23	19	31	20
	1–59	51	60	69	50	48	50	58	28	29	30	58	15	21	12	26	18
	60–189	52	57	60	43	51	56	62	40	21	21	38	16	13	13	19	21
	190+	52	55	62	45	54	51	58	40	20	25	40	12	13	14	20	11
Farm Organization	Family Holding	58	61	70	50	56	58	67	44	24	25	49	15	17	15	25	19
	Family Corporation	66	65	82	52	44	54	50	44	43	41	69	21	30	29	54	21
	Non-family Corporation	38	45	63	21	26	25	44	11	25	21	52	11	18	17	41	16
Sales/ha[2] ($)[3]	1–299	54	61	61	63	62	61	62	37	15	17	38	2	8	6	14	5
	300–600	64	70	77	60	71	68	72	60	21	24	49	10	12	10	19	13
	601–1300	75	69	83	73	63	59	79	55	43	36	63	24	30	22	29	27
	1301–2300	83	79	87	65	62	67	68	52	47	42	66	32	36	26	51	38
	2301+	67	71	69	66	49	63	53	50	35	37	52	27	29	32	40	29
Computer	Farm with	67	65	77	52	53	57	57	51	41	42	63	18	31	28	42	20
	Farm without	57	60	70	51	54	57	66	39	25	25	49	15	17	15	26	18

[1] Improved cropland (ha) categories for Prince Edward Island are: 1–17, 18–35, 36–60, 61–90, 91+

[2] hectare of improved cropland

[3] Sales/ha categories for Prince Edward Island and Newfoundland are: $1–$299, $300–$625, $626–$1500, $1501–$2700, $2701+

Manure

The Atlantic provinces use manure on a relatively large share of cultivated land (Table 3). All New Brunswick agricultural CCSs report manure use. Manure is used on more than 50 percent of cultivated land in 12 CCSs; four of these (Cardwell, Brighton, Saint Francois, Gladstone) report using it on more than 70 percent of cultivated land. Four CCSs use manure on twice the area receiving commercial fertilizer (Hillsborough, Kingston, Cardwell, Chatham).

In Nova Scotia, 43 CCSs report manure use. Manure is used on more than 50 percent of cultivated land in 12 CCSs. In two CCSs (Clare and Richmond Subdivision A) manure is used on an area larger than the area receiving commercial fertilizer.

In Atlantic Canada, Prince Edward Island farms report the lowest area receiving manure, although all CCSs reported the use of some manure. Manure is used on more than 25 percent of cultivated land in only five CCSs; in one CCS manure (Kings County, Lot 44) is used on an area larger than that receiving commercial fertilizer.

Manure use in Newfoundland is the highest in the country (Table 1). Manure is used on more than 80 percent of cultivated land in three CCSs (Division 1, Subdivisions E and 1; St. John's Metro Area); in four CCSs manure is used on an area greater than that receiving

commercial fertilizer (Division 1, Subdivisions C, E, and Y; St. John's Metro Area).

Manure is more commonly used on farms (Table 24):

- with larger improved cropland area (peaking for farms with 40 to 70 hectares of improved cropland)
- that have dairy (about 90 percent) or other cattle (about 78 percent)
- organized as a family unit
- with sales of $300 to 600 per hectare ($601 to $1300 for Prince Edward Island); however, manure use does not change much as sales changed.

Herbicides

Herbicides are not widely used in the Atlantic provinces, except on Prince Edward Island farms (Table 5). In New Brunswick, 10 CCSs report herbicide use on more than 50 percent of cultivated land; in six of these (Wilmot, Wicklow, Saint Quentin, Andover, Saint André, Drummond), herbicides are used on more than 60 percent of cultivated land.

Herbicides are used in 40 Nova Scotia CCSs, and six CCSs (Colchester Subdivision A, Cumberland Subdivisions A and B, Kings Subdivisions A and B, Annapolis Subdivision D) report herbicide use on more than 30 percent of cultivated land.

In contrast, all agricultural CCSs in Prince Edward Island report herbicide use. Herbicides are used on more than 50 percent of cultivated land in 26 CCSs; in eight of these (Prince County, Lots 19 and 25; Kings County, Lots 45, 47, 52, 53, 59; Queens County, Lot 21) they are used on more than 60 percent of cultivated land. Herbicide use is not common in Newfoundland.

Herbicides are more commonly used on farms (Table 24):

- with larger improved cropland area (in Prince Edward Island, herbicide use rises steadily as improved cropland area increases: it is three times as high on farms with more than 70 hectares of cropland compared to farms with less than 10 hectares of improved cropland; in New Brunswick and Nova Scotia there is little difference until farms have an improved cropland area of more than 70 hectares, when herbicide use more than doubles that on farms with less than 10 hectares of improved cropland)
- that grow potatoes
- where the farmer works off the farm fewer than 60 days in a year
- organized as a family corporation
- with sales of $1301 to $2300 per hectare
- with a computer.

Insecticides

The Atlantic provinces report the highest frequency of insecticide use in Canada (Table 5), although their use appears to be localized. In New Brunswick, three CCSs (Denmark, Saint André, Drummond) report using insecticides on more than 50 percent of cultivated land. Four Nova Scotia CCSs (Cumberland Subdivision B, Kings Subdivisions A and B, Shelburne) report insecticide use on more than 30 percent of cultivated land. In Prince Edward Island, insecticides are used on more than 23 percent of cultivated land, the highest in the country; five CCSs (Kings County, Lots 43, 45; Prince County, Lots 25, 27, 28) use insecticides on more than 40 percent of cultivated land. Insecticide use is not important in Newfoundland.

Insecticides are more commonly used on farms (Table 24):

- with larger improved cropland area (insecticide use is two and a half times as high in New Brunswick and Nova Scotia, and more than three times as high in Prince Edward Island on farms with more than 70 hectares of improved cropland compared to those with less than 10 hectares of improved cropland)
- that grow potatoes
- where the farmer does not work off the farm
- organized as a family corporation
- with higher per-hectare sales (peaking at sales of $1301 to $2300 per hectare in New Brunswick and Prince Edward Island and at sales of more than $2300 per hectare in Nova Scotia)
- with a computer (almost twice as much as on farms without, except in Newfoundland).

Erosion Control Practices

The Atlantic provinces generally use erosion control methods at or below the Canadian average (Table 7). Exceptions are the use of forages in crop rotations in Prince Edward Island, which leads the country in this practice, and, to a lesser extent, the use of windbreaks in Prince Edward Island and the use of winter cover crops in Nova Scotia.

In New Brunswick, all but one agricultural CCS reports using forages in crop rotations. More than half the farmers use forages in 30 CCSs; seven of these (Denmark, Grand Falls, Wakefield, Wicklow, Andover, Chatham, Perth) report that more than 70 percent of farmers use this method. Use of other erosion control methods is somewhat localized. More than 40 percent of farmers use grassed waterways in Grand Falls and Drummond. More than 30 percent of farmers use contour cultivation in the Saint André, Grand Falls, and Drummond CCSs. Windbreaks are rarely reported except in two CCSs (Gladstone reports that one third of the farmers use windbreaks).

In Nova Scotia, all but one agricultural CCS report using forages in crop rotations and 11 CCSs (Annapolis Subdivisions C and D, Antigonish Subdivisions A and B, Pictou Subdivisions A and B, Kings Subdivision B, West Hants, Cumberland Subdivision C, Cape Breton Subdivision A, Halifax Subdivision G) report that 40 percent of farmers use this method. In Kings Subdivision B, 48 percent of farmers use winter cover crops.

Forages in crop rotations are used in all Prince Edward Island agricultural CCSs. More than half the farmers report using this method in 57 CCSs; 80 percent of farmers in 10 CCSs (Queens County, Lots 20, 29; Prince County, Lots 6, 11, 14, 26, 27; Kings County, Lot 63; North River; 110003044) use this method. More than 30 percent of farmers use grassed waterways in three CCSs (North River, Prince County, Lots 27, 28). Contour cultivation is used by 35 percent of farmers in King's County, Lot 52.

All Newfoundland agricultural CCSs report using forages in crop rotations; in one CCS (Division 1, Subdivision E) this method is used on more than half the farms. Twenty-one percent of farmers use winter cover crops in Division 1, Subdivision Y, and 22 percent of farmers use windbreaks in Division 2, Subdivision E.

Crop and Forage Rotations

Including forages in crop rotations can improve soil structure, plant nutrition, root growth, and the control of weeds, pests, and disease. A combination of crop rotation and residue management can increase the activity of soil microbes, decrease the build-up of harmful soil bacteria, and provide the crop variety needed for top productivity.

Forages play an important role in conserving the soil resource. Depending on the type of crop grown, crop residues and root mass can increase soil organic matter and improve soil physical properties.

In Atlantic Canada, research is focussed on livestock feed and potato rotations. The effects of residue on soil structure and water infiltration, crop disease, and nitrate leaching are currently under study.

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Erosion control methods are generally used more on farms (Table 25):

- with larger improved cropland area (the use of forages in crop rotations increases steadily as improved cropland area increases, but the use of winter cover crops, grassed waterways, and contour cultivation increases sharply for farms in the largest improved cropland area category; windbreaks are most common on farms with the largest improved cropland area)
- that have dairy cattle (forages in crop rotations), or grow potatoes (winter cover crops, grassed waterways, contour cultivation)
- where the farmer does not work off the farm (forages in rotations, winter cover crops), or works off the farm fewer than 60 days in a year (grassed waterways, contour cultivation)
- organized as a family corporation
- with higher per-hectare sales, peaking at sales of $1301 to $2300 per hectare
- with a computer (although there is little difference compared to farms without for the use of forages in rotations).

Tillage Practices Used to Prepare Land for Seeding

Conservation tillage, including no-till, is not as widely practised in the Atlantic region

Table 25: Erosion control practices in the Atlantic provinces, 1991 Census (percent of farms reporting; New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland, respectively).

Selected Variables		F				WCC				GW				CC				WB			
Improved Cropland (ha)[1]	1–9	20	13	46	25	6	7	4	5	4	3	5	2	5	5	4	4	8	6	16	8
	10–20	26	25	59	40	5	9	3	10	6	6	5	8	7	5	7	11	6	6	13	18
	21–40	40	30	73	37	4	8	7	9	5	7	6	4	5	8	7	9	6	5	12	7
	41–70	51	47	79	44	9	15	7	5	6	13	10	2	7	11	10	5	7	7	14	7
	71+	64	61	84	27	18	20	17	0	17	14	22	2	14	9	18	2	9	9	18	10
Farm Type	Dairy	53	50	80	29	7	12	5	1	8	11	8	3	4	9	8	5	8	6	13	5
	Cattle	33	32	55	14	3	6	2	0	5	7	4	1	4	5	4	1	4	4	11	8
	Other Livestock	18	19	48	9	3	8	5	3	3	6	8	2	3	5	8	1	4	6	13	4
	Hay and Fodder	31	28	56	41	4	2	2	11	6	6	0	3	4	4	0	3	2	6	7	8
	Potato	76	39	81	35	31	54	13	0	23	8	21	0	24	12	17	12	11	8	14	12
Days Off-farm Work	None	38	30	67	24	9	11	9	5	9	7	11	2	8	6	10	5	7	7	14	7
	1–59	30	25	68	30	6	12	6	5	8	7	14	8	7	6	9	5	7	8	18	5
	60–189	32	28	57	20	8	8	3	2	3	4	4	3	5	7	5	4	6	5	11	10
	190+	30	23	56	23	6	7	7	6	5	7	8	2	5	6	7	4	7	5	15	9
Farm Organization	Family Holding	34	27	63	26	7	9	7	5	6	6	8	3	6	6	8	4	6	6	13	9
	Family Corporation	49	33	67	22	16	21	18	3	15	12	24	3	12	6	14	8	11	10	21	8
	Non-family Corporation	16	16	63	21	8	9	15	0	7	7	22	0	4	3	15	0	5	0	19	11
Sales/ha[2] ($)[3]	1–299	32	30	59	21	4	5	5	5	4	6	5	3	5	5	5	1	6	6	15	10
	300–600	39	34	68	26	5	8	5	5	6	7	7	3	5	7	10	7	6	6	13	2
	601–1300	48	32	76	30	11	11	7	11	8	7	11	2	9	7	10	4	8	6	13	8
	1301–2300	54	37	75	47	17	13	15	3	15	8	19	7	11	9	15	7	10	7	18	15
	2301+	37	30	56	33	11	19	11	5	11	10	11	4	10	9	8	8	8	8	16	12
Computer	Farm with	43	37	68	30	18	23	21	11	17	11	26	9	13	9	14	3	13	10	27	14
	Farm without	34	27	63	23	7	8	7	4	6	6	8	2	6	6	8	5	6	6	13	7

[1] Improved cropland (ha) categories for Prince Edward Island are: 1–17, 18–35, 36–60, 61–90, 91+

[2] hectare of improved cropland

[3] Sales/ha categories for Prince Edward Island and Newfoundland are: $1–$299, $300–$625, $626–$1500, $1501–$2700, $2700+

F = Forages in rotations, WCC = Winter Cover Crops, GW = Grassed Waterways, CC = Contour Cultivation, WB = Windbreaks

as in other parts of Canada (Table 11). In New Brunswick, conservation tillage or no-till is used on more than 25 percent of land prepared for seeding in four CCSs (Cambridge, Saint Lonard, Saint Paul, Saint John County). No-till is rarely used; only Saint Paul reports a significant area receiving no-till (about 45 percent).

In Nova Scotia, conservation tillage or no-till is used on more than 15 percent of cropland prepared for seeding in five CCSs (East Hants, West Hants, Cumberland Subdivisions C and D, Colchester Subdivision C).

In Prince Edward Island, three CCSs (Prince County, Lots 17, 25; Queens County, Lot 34) report using conservation tillage or no-till on more than 20 percent of seeded cropland.

In Newfoundland, conservation and no-till are practised only in the St. John's Metro Area.

A comparison of tillage practices (Table 26) shows:

- the use of conventional tillage becomes more important as cropland area increases: it is more than five times as high on farms with more than 60 hectares of improved cropland compared to farms with less than five hectares of improved cropland in Prince Edward Island, and more than three times as high in new Brunswick
- the use of conservation tillage increases more rapidly than the use of conventional tillage with increased per- hectare sales
- farms with a computer are more likely to use conservation tillage than those without, but there is little difference for conventional tillage and no-till.

Table 26: Tillage practices in the Atlantic provinces, 1991 Census (percent of farms reporting; New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland, respectively).

Selected Variables		Conventional Tillage				Conservation Tillage				No-till			
Improved Cropland (ha)[1]	1–4	46	32	65	61	5	7	3	5	5	3	7	3
	5–15	59	39	76	59	7	6	6	10	2	4	6	8
	16–35	57	54	87	60	5	4	8	9	4	3	4	10
	36–60	68	68	93	67	4	7	12	0	3	3	3	4
	61+	84	84	96	79	18	10	15	8	4	8	2	4
Farm Type	Dairy	69	71	87	52	6	8	8	5	4	6	4	8
	Cattle	50	48	62	28	3	4	5	4	3	4	5	8
	Other Livestock	29	28	58	13	3	4	7	1	1	2	3	3
	Hay and Fodder	39	41	42	35	6	5	2	3	2	1	2	3
	Potato	95	92	96	100	26	8	13	6	4	15	2	0
Days Off-farm Work	None	56	46	79	43	8	6	9	4	3	4	4	4
	1–59	41	43	77	53	8	4	11	5	6	4	1	5
	60–189	48	45	64	32	5	5	7	8	2	3	3	2
	190+	44	36	63	38	4	4	5	2	2	3	4	4
Farm Organization	Family Holding	51	43	74	43	6	5	7	5	3	4	4	4
	Family Corporation	60	51	81	40	13	7	21	6	3	4	1	3
	Non-family Corporation	35	26	56	26	10	4	19	0	4	3	7	0
Sales/ha[2] ($)[3]	1–299	52	45	74	28	5	5	6	5	3	4	4	6
	300–625	58	48	81	39	6	6	9	5	4	5	6	5
	626–1500	64	48	87	64	9	5	10	4	4	4	3	3
	1501–2700	76	59	86	70	14	7	11	10	5	5	3	7
	2701+	60	54	71	59	8	8	8	6	2	4	4	5
Computer	Farm with	58	52	80	38	10	10	14	7	3	5	3	9
	Farm without	51	42	74	41	6	5	8	4	3	3	4	3

[1] Improved cropland (ha) categories for Prince Edward Island are: 1–14, 15–30, 31–50, 51–80, 81+

[2] hectare of improved cropland

[3] Sales/ha categories for Prince Edward Island and Newfoundland are: $1–$299, $300–$625, $626–$1500, $1501–$2700, $2701+

GLOSSARY

Census Agricultural Region (CAR): a subprovincial geographic unit used by the Census of Agriculture to disseminate agricultural statistics; in the Prairies, CARs are commonly called crop districts; in Saskatchewan, CARs are groupings of census consolidated subdivisions, but these groupings do not necessarily follow census division boundaries; CARs have not been defined for Prince Edward Island

Census Consolidated Subdivision (CCS): the smallest geographical unit for which agricultural census data are available; a grouping of small census subdivisions (municipalities, towns, townships, cities, parishes, and so forth) within a census division with a combined land area greater than 25 square kilometres; a census subdivision with a population greater than 100,000 according to the 1986 Census usually forms a CCS on its own

Census Division (CD): a geographic area established by provincial law, which is intermediate between the census subdivision and the province and corresponds to counties, districts, regions, district municipalities, regional districts, regional municipalities, united counties, and so forth

Contour Cultivation: cultivation that follows the contour of a field, at angles to the slope of the field

Conservation Tillage: tillage methods leave most of the crop residue (trash) on the surface of the soil (including minimum tillage methods)

Conventional Tillage: tillage methods that incorporate most of the crop residue (trash) into the soil

Cropland: the total area on which field crops, fruits, vegetables, nursery products, and sod are grown

Cropping intensity: the share (per cent) of total farm area that is improved cropland

Erosion: a process that removes material from the soil, resulting in soil degradation; can be caused by wind, water or tillage

Family corporation: a farm that is owned and operated by a family and that is legally incorporated

Family holding: a farm that is owned and operated by a family

Family unit: a family holding or family corporation

Fertility: the ability of a soil to provide nutrients to plants

Fertilizer: any commercially prepared fertilizer

Forages in rotations: planting forage crops, like alfalfa or clover, in crop rotations

Grassed waterways: grassy strips in run-off depressions in cultivated fields that provide a route for excess water

Improved cropland: the sum of cropland, summerfallow, and improved pasture

Improved pasture: area improved by seeding, draining, irrigating, fertilizing, brush or weed control, not including areas where hay, silage, or seeds are harvested

Irrigation: application of water to cropland

Manure: Livestock or poultry waste applied to cropland

Non-family corporation: a farm that is legally incorporated, but not owned and operated by a family

No-till: a tillage method where the soil is not disturbed between harvesting one crop and planting the next (including direct seeding into stubble or sod, and ridge tillage); also referred to as zero-till

Soil degradation: a decline in soil health, resulting in lower productivity

Strip-cropping: alternating strips of crop and summerfallow, or of two crops, across a field; if used for control of wind erosion, the strips are usually at right angles to the prevailing winds.

Summerfallow: area that has been left idle (not worked) for at least one year

Sustainable: referring to land management practices that allow the land to be healthy and productive for years to come

Total farm area or farmland: all lands owned, rented, or sharecropped, including all land for crops, grazing and pasture, summerfallow, buildings and barnyards, bush, sloughs and marshes, etc.

Windbreak: a natural or planted line of trees or bushes at the border or within a field; also called shelterbelt

Winter Cover Crops: crops, such as fall rye and winter wheat, that are planted after the fall harvest as a means of soil protection

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